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CHAPTER I

GENERAL NATURE OF INDUCTION

1. **The Problem of Induction.**—The syllogism is no better than a hypothetical judgment, because the conclusion is true only *if* the premisses are true.[1] The problem remains: how do we establish the premisses themselves? All syllogistic reasoning is the application of a generalisation, a law, a principle, to particular facts and cases; hence, we have now to examine the ground on which generalisations are based.

The primary source of all our knowledge is experience; but obviously it gives us knowledge of particular facts only, not of general principles. For instance, experience teaches us that men died in the past, that they die at present, but it cannot justify our belief in the mortality of *all men*, including those yet to be born. Again, even without examining *all* peacocks we confidently assert that they are blue. We examine only *one* triangle and generalise that the sum of the three angles of *any* triangle is equal to two right angles. The problem of Induction is to find out the justification for taking this leap towards generalisation from only one or few observed cases, to examine the grounds on which we base inferences of universal laws from particular facts.

[1]cf The author's *Elements of Deductive Logic*, Calcutta, 1918. Book III, ch 4.

How do we arrive at universal propositions, which experience is incapable of yielding? This is the question that states the problem of Induction.[1]

2. **The Meaning of Induction.**—If Induction aims at the discovery of universal laws which express the essential nature of phenomena, it must be regarded as the most adequate and necessary instrument for the advancement of Science. For that reason Inductive Logic is also known as the Logic of Science. Science seeks to understand nature and to control it by the power of knowledge. Such knowledge is only possible by strict loyalty to facts: hence scientific thought is always controlled by *facts*. The progress of science is effected by an appeal to facts at every stage.[2] Science always aims at the formulation of most general hypotheses, which, duly verified, become universal principles.

The term 'Induction' covers the whole process of scientific explanation, which means that it involves Deduction as well.[3] But sometimes it is used in a more restricted sense, *viz.*, the observation of facts and the formulation of a hypothesis. We consider such restriction to be more or less arbitrary, since it assumes that Induction and Deduction are always to be kept apart—

[1] "Why is a single instance, in some cases, sufficient for a complete induction, while in others myriads of concurring instances, without a single exception, known or presumed, go such a very little way towards establishing an universal proposition? Whoever can answer this question knows more of the philosophy of logic than the wisest of the ancients, and has solved the problem of Induction".—Mill, *Logic*, III. iii 3.

[2] "The triumphs of science have been due to an insistence on *facts*. The victories have been won by turning away from vague armchair speculation, and by *exact observation* of what actually occurs. The result of this laboratory method is that the scientist now speaks with unparalleled authority."—*Quakerism, a Religion of Life*, London, 1908, p. 21.

[3] *Vide* ch. VII *infra*.

an assumption which falls short of truth. Induction and Deduction are to us only aspects or stages of one and the same process.

Aristotle defines Induction as the process of 'establishing a general proposition by appeal to the particular instances in which its truth is shown'. The doctrine of Induction was, however, not worked out in any detail either in Traditional or in Scholastic Logic. Although Roger Bacon (1214—1294) had insisted on testing the value of theories by reference to concrete facts and had spoken of man as the interpreter of nature, the credit of founding Induction is usually given to Francis Bacon, Lord Verulam (1561—1626), who elaborated the Inductive method for the interpretation of nature. He viewed Induction as the discovery of "forms" (*i.e.*, the essence) of things. After him, J. S. Mill (1806—1873) defined Induction as the process of discovering and proving general propositions. He considered all inference as inductive, and a procedure from the known to the unknown. Bain defines Induction as the arriving at general proposition, by means of Observation or Fact. Venn regards it as the objective counterpart or foundation of inferribility. According to Jevons, Induction is essentially enumerative: 'Perfect' Induction—"in which all the objects or events which can possibly come under the class treated have been examined—gives us certainty, while 'Imperfect' Induction cannot take us beyond probability. In inductive reasoning, as in the deductive, the conclusion never passes beyond the premisses. Sigwart[1] speaks of Induction as the inversion of the syllogism, and Bosanquet[2] defines it as 'the reference to reality of a system or the ground of particular

[1] cf. Sigwart, *Logik*, II. 401.

[2] cf. Bosanquet, *Logic*, 179, 43 ff.

differences within it by which reality is taken as qualified.' Wundt considers the elementary logical form of Induction as a syllogistic argument in the Third Figure (*Verbindungsschluss*).

3. **Relation between Induction and Deduction.**—We have spoken of Induction and Deduction as two *aspects* of the same process. They are distinctions within unity, moments of the same process. Deduction cannot proceed without a generalisation in the form of the major premiss, and such generalisation can only be arrived at by means of induction. On the other hand, induction also involves deduction, without which it cannot complete itself. Hence such like statements as 'Inference is essentially deductive' (Hamilton), 'Inference is at bottom inductive' (Mill) err in being one-sided, and do not state the whole truth. The fact is that inference is a complex process involving both induction and deduction; neither is less important than the other. A rigid separation between the two is impossible. Keeping this in mind, we may still distinguish the two aspects of the inferential process.

It is usual to distinguish Induction and Deduction as converse processes. Thus it is said that Induction proceeds from the particular to the more general, and Deduction from the general to the more particular. In the former we attempt to explain particular facts by discovering their interconnexion and state it in the form of a general law; in the latter we start with a general law and apply it to particular cases, thereby proving the existence of a certain attribute in a particular subject, Induction proceeds from facts to reasons that explain those facts. Deduction proceeds from conditions to their consequences. The former is essentially an instrument of discovery and explanation, the latter of verification

and proof. Induction reduces multiplicity to the unity of a law; it finds unity and uniformity within diversity; it seeks the one in the many; it attempts to organise the vast mass of details and facts into an ordered and systematic whole. Deduction, on the other hand, tests the validity of a universal principle or a general law; it proves the truth of a law by its application to fresh cases; it demonstrates a truth by applying it to particular relevant facts; it traces the consequences of a certain condition assumed to be true. Both these processes are mutually supplementary.[1]

The following Table summarises the characteristics of Induction and Deduction:—

Induction.	Deduction.
1. *Principle:* 'What is true of each is true of all.'	1. *Principle:* 'What is true of all is true of each."
2. Proceeds from part to whole.	2. Proceeds from whole to part.
3. Inference viewed from the side of differences.	3. Inference viewed from the side of the Universal
4. Starts with individuals and ascends to universal laws.	4. Starts with universal laws and descends to individuals.
5. Experience the starting-point.	5. Independent of Experience.
6. Proceeds from facts to reasons.	6. Proceeds from reasons to their consequences.
7. Aims at *truth*.	7. Aims at *validity*.
8. *Goal:* Causal explanation of phenomena.	8. *Goal:* Application of a universal principle to facts.

[1] cf. what Riehl says on Induction: 'No Induction is possible without Deduction. Induction is a hypothetical Deduction, a conjecture by means of a Deductive syllogism.' Also cf. "The distinction between Induction and other forms of Inference, erroneously described as the distinction between Induction and Deduction, is chiefly a distinction of *aspects*, largely based on a confused idea of Induction, but yet in some degree justified."—Bosanquet, *Logic*, II. 18.

Induction.	Deduction.
9. Reduces multiplicity to the unity of a law.	9. Proves the truth of a law by its application to fresh cases.
10. Characterised by novelty in its result.	10. Novelty only psychological, not strictly logical.
11. Instrument of *discovery*	11. Instrument of *verification* and *proof*.
12. First premiss a *fact*.	12. Major premiss a *principle*
13. Copula "constitutes"	13. Copula "is."
14. Commonly prior to and independent of Deduction	14. Usually posterior to and dependent on Induction

Thus we see that although inference is a single process, the distinction between Induction and Deduction is not absolutely meaningless. Bosanquet holds that Induction has hardly any claim to be classed as a species of Inference.[1] Boyce Gibson too objects to the use of the term "Inductive Inference," which he regards as a "misnomer." But if we keep in view the real basis of distinction between Induction and Deduction, no reasonable objection could be preferred against the time-honoured and familiar term. What may, with some justification, be objected to, is the antithesis often set up between Inductive and Deductive Logic. Deductive Logic treats of several inferences which are inductive in the commonly-accepted sense, while Inductive Logic proceeds on a method which cannot complete itself without the aid of deduction. Thus Inductive and Deductive Logic are not to be treated as two water-tight compartments.

[1] "It has not for its differentia any peculiar nature in the universal which carries the conclusion. It is, consequently, like Comparison or Recognition, like Observation or Experiment, a transient and external characteristic of inference."—Bosanquet, *Logic*, II. 176.

Logic is *one*: it treats of inference which involves both induction and deduction At the same time, we must not forget that for the sake of clearness *distinctions* are often necessary although they must not be transformed into *divisions*. We have ourselves divided our exposition of logical principles into two parts, and have named them in the usual way, without in any sense recognising or implying any antithesis between Inductive and Deductive Logic.

4. **The Inductive Syllogism.**—Aristotle understood by Induction the process of establishing a universal proposition by showing empirically that it is true in each particular case relevant to the inquiry. This kind of Induction—called Perfect Induction (*vide* ch. II)—can be stated in the form of a syllogism:—

Man, horse, ass ... are long-lived.
Man, horse, ass ... are animals without bile.
∴ All animals without bile are long-lived.[1]

If this syllogism is to be true, its minor premiss must be convertible "simply"; it must comprise all the particulars, *i.e.*, the members in the enumeration must be commensurate with the class. The Inductive Syllogism may, therefore, be expressed in the following symbolic form:—

S_1, S_2, S_3 are P,
S_1, S_2, S_3 alone are M,
∴ All M is P.

Aristotle describes it as an argument 'by which we prove the major term to be true of the middle term, by means of the minor term'. If the conclusion 'All M is P' is taken for nothing more than an *enumerative judgment*, it will not serve as a true universal proposition

[1] Aristotle, *An. Prior*, II. c. 23. Also cf. *An. Post.* II. c. 17.

which science requires. To fulfil that purpose it must show that there is a law of connexion between M and P.

Strictly speaking, the Inductive Syllogism, though valid in the above sense violates the syllogistic rules,[1] since, in the minor premise, the copula is not "are" but "constitute" or "make up" (which is the real meaning of "are" here). While each of the instances in the major premise is P, those of the minor premise constitute M *all together*. In this sense, then, M is used collectively in the minor premise and distributively in the conclusion; hence the conclusion 'All M is P' cannot be valid. It is only valid if the enumeration is complete; thus:—

Valid.	*Invalid.*
S_1, S_2, S_3 are P.	S_1, S_2, S_3 are P
S_1, S_2, S_3 alone are M.	S_1, S_2, S_3 are all M.
∴ All M is P.	∴ All M is P.

The *valid* form of the Inductive Syllogism, as given above, may also serve as a symbolical expression of "Perfect Induction"; and we may also note in passing that it is just the inverted form of the Deductive Syllogism:—

Perfect Induction: as Inductive Syllogism.	*Deductive Syllogism.*
Spring, Summer, Autumn and Winter make up a year.	The four seasons make up a year.
Spring, Summer, Autumn and Winter are the four seasons.	Spring, Summer, Autumn and Winter are the four seasons.
∴ The four seasons make up a year.	∴ Spring, Summer, Autumn and Winter make up a year.

So, too, the principle of Perfect Induction is just the reverse of the *Dictum de omni et nullo*, and may be stated as: "What is affirmed (or denied) of all the

[1] "This argument violates the rules of the syllogism, and yet it is perfectly valid. The reason of this is that the rules of syllogism are not designed to meet the case of a quantified predicate such as we have in the second proposition."—Stock, *Logic*, p. 142.

logical parts, may be affirmed (or denied) of the logical whole": *or* "What is true of each is true of all".

5. **Reduction of Inductive Syllogism to Deductive form.**—Attempts have been made to exhibit the Inductive Syllogism into the Deductive form, but the transformation seems to be more or less unnatural, since the true inductive character of the argument still persists. There is an outward similarity to the deductive form, but also an underlying substantial difference[1]—

Whatever belongs to each individual belongs to the whole class.
Attracting iron belongs to this, that, and the other magnet.
∴ Attracting iron belongs to all magnets.

The following example given by Whately shows how Induction can be forced into the Deductive form;—

Whatever belongs to the individuals we have examined, belongs (certainly or probably as the case may be) to the class under which they came.
Sheep, Ox, Deer, are found to ruminate, while they belong to the class of animals deficient in the upper cutting teeth.
∴ All such animals are ruminant.

The unnatural and uncouth form of such arguments is obvious. Whately argued that—

All Reasoning is Syllogistic.
Induction is a form of Reasoning.
∴ Induction is Syllogistic.
∴ Induction is Deductive.

[1] On this point read Karlslake, *Aids to the Study of Logic*, Oxford, 1851, pp. 92 ff. According to Aldrich, Induction is a Syllogism in the first mood of the first Deductive figure, of which the Minor is suppressed.

But, as a matter of fact, the Syllogism is not identical with Deduction. Besides, to say that all Reasoning is Syllogistic is to say nothing: it is mere tautology like 'All reasoning is reasoning'. Thus, we hold that all attempts to force Induction into the Deductive form are bound to be futile. While it is true that Induction and Deduction are only two aspects of the Inferential process we must also observe, while admitting their distinction, that the principle of Induction is precisely the inverse of that of Deduction.

6. **The Method of Induction.**—The analysis and investigation of phenomena is conducted by the method of Induction, which involves the following steps:—

(*i*) Perception of connexion between phenomena in some particular case or cases.

(*ii*) Formation of a Hypothesis as suggested by such observation.

(*iii*) Deduction of the consequences of this Hypothesis.

(*iv*) Testing of these consequences with reference to a careful study of phenomena, and the exact formulation of the hypothesis, which, after verification, is accorded the dignity of a theory or law.

DeMorgan describes this Method as follows:—

"Modern discoveries have not been made by large collections of facts with subsequent discussion, separation, and resulting deduction of a truth thus rendered perceptible. A few facts have suggested an *hypothesis*, which means a *supposition* proper to explain them. The necessary results of this supposition are worked out, and then, and not till then, other facts are examined to see if these ulterior results are found in nature. The trial of the hypothesis is the *special object*; prior to which hypotheses must have been started, not by rule, but by that

sagacity of which no description can be given, precisely because the very owners of it do not act under laws perceptible to themselves. The inventor of hypotheses, if pressed to explain his method, must answer, as did Zerah Colburn, when asked for his mode of instantaneous calculation. When the poor boy had been bothered for some time in this manner, he cried out in a huff, 'God put it into my head, and I can't put it into yours.' Wrong hypotheses, rightly worked from, have produced more useful results than unguided observation."[1]

7. **Bacon's Pure Inductive Method.**—Bacon and his followers adopted, in conducting their investigation of Nature, a method known as the Pure Inductive Method. It was a reaction against the authority of dogma in the days of Scholasticism. The tendency to allow facts to speak for themselves served as the origin of this method, which aims at strict Fidelity to Fact by avoiding Hypothesis altogether. Creighton describes this method thus:—"Knowledge, then, must begin with observation of particular facts; and only after we have made a great number of particular observations, and have carefully classified and arranged them, taking account of all the negative cases, are we able to discover in them the general law. No hypotheses or guesses are to be made; but we must wait until the tabulations of the particular phenomena reveal the general 'form' or principle which belongs to them all".[2] It is a laborious method by which we keep on compiling statistics till the general 'form' is revealed by itself. We are not required to frame any hypothesis, in order to remain strictly within the arena of facts.

But this comparatively primitive notion is rejected by

[1] cf *Budget of Paradoxes*, p. 55.

[2] Creighton, *An Introductory Logic*, New York, 1909, p. 29.

modern logicians. Hypothesis is now held as an absolutely necessary accessory to Induction. Fidelity to facts, though good in itself, is not everything "The mind cannot collect facts methodically unless it also selects them.... It is not enough to be faithful to fact. Science must be faithful to *its own* facts, to the facts *relevant* to its own ideas. What Induction needs as its guiding principle is not a vague Fidelity to Fact, but Fidelity to Relevant Fact.[1] Thus, according to the modern conception of Induction, mere empirical collection of facts is not enough: the mind must know the purpose for which the collection is made. Hence the use of Hypothesis is indispensable. It is Hypothesis which gives meaning to Fact. Bacon's Pure Inductive Method is, therefore, not suitable for the progress of science, and is incompatible with the most modern conception of Induction, which makes Hypothesis a most indispensable step in the inductive process

SUMMARY.

All syllogistic reasoning is based on the assumption of the formal truth of the major premise. The Problem of Induction is to inquire how we arrive at the major premiss; in other words, to find out the grounds of generalisation. Experience can give us knowledge of the particular only. How, then, do we derive from it universal principles, how do we generalise from concrete facts? That constitutes the Problem of Induction.

Induction is the most adequate and necessary instrument of Science, which aims at the establishment of universal laws. For that reason, Inductive Logic has also been called the Logic of Science.

[1] W. R. B. Gibson, *The Problem of Logic*, London, 1908, p. 314.

To Aristotle Induction signified the establishing of a general proposition by showing that it is true in each particular case. The doctrine of Induction, though not unknown to the ancient Greek or the mediæval scholastic logicians, has been elaborated only in modern times. Roger Bacon, and three centuries later Francis Bacon, laid the foundations of the Inductive Method, but the doctrine did not receive very great impetus till the appearance of J. S Mill, who held all inference to be inductive, reasoning from particulars to particulars, from the known to the unknown.

Induction is most intimately related to Deduction in fact, they are two *aspects* of the inferential process. Induction by itself is never complete without deduction; while deduction starts with the generalisation which can only be reached through induction. But a useful distinction could be drawn between these two aspects, if we do not lose sight of their essential relation. (See p. 8).

Aristotle had attempted to bring Induction in the form of a syllogism, and defined Inductive Syllogism as an argument that proves the major term of the middle by means of the minor, thus—

S_1, S_2, S_3, (*minor*) are S (*major*),
S_1, S_2, S_3, alone are M (*middle*),
∴ All M is P.

If we substitute "are all" in place of "alone are" the syllogism becomes inadmissible. The Inductive Syllogism in the form given above is the inverse of the Deductive Syllogism. Its transformation into the deductive form is unnatural, since the inductive character survives the mere outward change.

The method of Induction comprises the following steps:—(1) Observation of connexion between phenomena, (2) Formation of hypothesis, (3) Testing the

hypothesis, (4) Verification and Explanation. Bacon's Pure Inductive Method proposed to eliminate Hypothesis altogether and to discover the general form by a methodical study of facts themselves. But relevancy is very essential to science; a mere collection of facts is useless; hence the use of hypothesis cannot but be admitted as absolutely necessary, consequently Bacon's Method must be rejected as unsound and erroneous.

Questions and Exercises.

1. Distinguish between *formal* and *material* truth. Which of the two is aimed at in Induction?
2. State the general problem of Induction.
3. Why has Inductive Logic been called the "Logic of Science"?
4. Give Aristotle's definition of Induction. Was the problem of induction discussed at any length by formal logicians?
5. Discuss the relation between Induction and Deduction.
6. In what sense is the inductive process opposed to the deductive?
7. "Induction is always a syllogism". Is this a true analysis of the process of inductive reasoning?
8. "Induction proceeds from facts to reasons; Deduction from conditions to consequences." Explain this statement.
9. "Induction is a hypothetical deduction." How far does this statement explain the relation between Induction and Deduction?
10. Indicate very briefly how Induction is never complete without Deduction, and how Deduction is based on Induction.
11. Explain:—"In the actual conduct of scientific inquiry there is a constant alternation of the processes of induction and deduction."
12. Critically examine the following observations:—
    (*i*) "Induction is really the inverse process of Deduction."
    (*ii*) "Induction and Deduction are continuous operations."

(*iii*) "The Third is distinctively the *Inductive figure.*"

13. What is common to the inductive and deductive processes of reasoning? In what do they differ?

14. Compare and discuss the views of Mill and Jevons regarding the nature of Induction.

15. Criticise the attempts to state inductive reasoning syllogistically?

16. Point out the futility of Whately's attempt to force Induction into the Deduction form.

17. Analyse the general Method of Induction, and set down the various stages in the inductive process.

18. Characterise Bain's Pure Inductive Method and point out its chief drawbacks.

19. Critically consider the various views that have been advanced respecting the logical form of Induction

20. "What is true of each is true of all." Estimate the value of this principle.

CHAPTER II

"PERFECT" AND "IMPERFECT" INDUCTION

1 **Perfect Induction.**—An Induction is "Perfect"[1] when *all* the instances covered by a rule have been examined and found true. This form of Induction exhausts all the possible cases, and therefore depends on a *complete numeration.* Thus, if there are 100 students in my class, and none of them is able to answer a few simple questions in Geography, I am led to assert that my class is ignorant of Geography. Again, when I see that each of the twelve months of the year contains more than 27 and less than 32 days, I may at once assert that all the months contain more than 27 and less than 32 days. Here the enumeration is *complete*, as all the possible instances have been examined before framing the rule.

Many modern logicians question the right of "Perfect" Induction to be classed as inference at all, since the conclusion, instead of being more general than the premises, merely sums up what is already stated in them. They look upon it as Induction *improperly so-called* or *apparent* Induction. Others,[2] however, hold that the true road to certainty lies in complete enumeration.

[1] "Perfect" Induction is the only 'formally valid' Induction, according to Aristotle, while according to Mill it has no right to be classed under Induction at all, since it fails to lead us on to the unknown.

[2] *e g.* Jevons cf. his *Principles of Science*, 2nd ed. I. pp. 146-152.

2. **Imperfect Induction.**—This type of Induction requires the examination of a few instances only. It rests on the assumption of similarity between the examined and the unexamined cases.[1] Sometimes even a single case is enough to form the basis of such Induction. By an acute analysis we understand its essential nature and are led to assume similarity in like cases *unexamined* by us. The superiority of the "Imperfect" over the "Perfect" type of Induction lies in the fact that by the discovery of an inner connection between phenomena or the instances examined it does away with the necessity of examining *all* possible cases.

Imperfect Induction may be subdivided into (*i*) Induction by Simple Examination (*Inductio per simplicem enumerationem*) and (*ii*) Scientific Induction.

3. **Induction by Simple Enumeration.**—This kind of induction consists in establishing a universal truth on the ground of *mere* enumeration of instances, without any attempt to explain any causal connexion. We examine several cases, and finding that none of these contradicts our hypothesis, we argue that what is true of these instances is also true universally. For example, I go to inspect a school, and put a few questions to some students indiscriminately: if the first four students answer correctly, I expect the fifth also to give me the correct answer. I infer that all boys of that class are smart and intelligent. In the case of Perfect Induction, it was necessary to question *each* boy before drawing

[1] "Imperfect Induction merely unfolds the information contained in past observation or events; it merely renders explicit what was implicit in previous experience. It transmutes knowledge, but certainly does not create knowledge" (*ibid* I. 168 *ff.*) "In inductive, just as in deductive reasoning, the conclusion never passes beyond the premisses." (*ibid* I. 251).

any conclusion about the whole class: it required *complete enumeration.* But Induction by *Simple* Enumeration differs from that by *Complete* Enumeration ("Perfect") in that its conclusion is not a mere compendious statement of its premisses but is more general, referring to more than what is covered by the instances actually examined. Moreover, we make no attempt to show that the conclusion we have drawn from the instances examined is the only one which the facts in question allow; if we do so, it becomes Scientific Induction, of which we shall speak presently.

How do we arrive at the conclusion that 'All men are mortal"? Only by *simple enumeration.* The conclusion cannot be arrived at by Perfect Induction, since in this case *complete enumeration* is out of the question. We know some men who died and those who are dying; and finding that our experience is not contradicted in these instances, we rise to the conclusion that '*all men*' (past, present and future) are 'mortal.' Similarly, we meet a few Frenchmen, find them very hospitable and amiable, and we infer that 'All Frenchmen are hospitable and amiable.' The leap from '*some*' to '*all*' is based on our faith in the Uniformity of Nature, in the existence of universal relations and interconnexions in Nature. The following are the steps usually taken in establishing a universal truth by *inductio per simplicem enumerationem* :—

(*i*) We observe that a few instances, *viz.* a, b, c, d, possess a common characteristic x.

(*ii*) But the instances in question belong to the class Z; therefore, perhaps *all* instances belonging to the class Z possess the characteristic x.

(*iii*) We may verify this generalisation by applying it to other instances, a', b', c', d' . . . . , which also belong to the class Z.

We do not attempt at any *complete* enumeration of cases but examine only a few instances and infer a certain general truth on the strength of *mere* enumeration. It is obvious that there is always the possibility of an incomplete elimination in this method, hence the conclusion is not absolutely *certain* but only *probable*.[1] Its principle is that what is to be will *probably* be like what has been in similar circumstances. But if the number of instances examined is large enough, the unessential elements are more easily eliminated and the chances of error reduced.[2]

Induction by Simple Enumeration "which proceeds by merely citing instances, is", according to Bacon, "a childish affair, and being without any certain principle of inference it may be overthrown by a contradictory instance. Moreover, it usually draws the conclusion from too small a number of instances, taking account only of those that are obvious".[3] It is called "a

[1] "Nature is to us like an infinite ballot-box, the contents of which are being continually drawn, ball after ball, and exhibited to us. Science is but the careful observation of the succession in which balls of various character usually present themselves; we register the combinations, notice those which seem to be excluded from occurrence, and from the proportional frequency of those which usually appear we infer the probable character of future drawing." Jevons, *ibid*, I, 169; also cf. I. 292 ff.

[2] On the counting of instances is based the Statistical Method usually applied to sociological problems these days. Prof. E. W. Scripture (cf. *The New Psychology*, pp. 16 ff.) gives the following rules of this method:—(1) The Phenomenon to be counted must be a countable fact that can serve as a unit, (2) All things which are to be counted shall correspond completely and exactly to the stated definition of the counted object, and nothing that does so correspond shall be omitted.

[3] *Novum Organum*, Bk. I. aph. cv.

childish thing" (*res puerilis*), because it merely assumes a uniform interconnexion of two phenomena, without attempting to analyse them as parts of a coherent system, but until that is done we have merely empirical knowledge of a certain fact but no adequate explanation. It is Scientific Induction which undertakes to carry on this deeper analysis in the search after true explanation. Hence the fundamental limitation of this type of Induction is that it fails to establish any causal connexion between phenomena but only states a fact of uniform connexion.[1] Enumeration is, however, not entirely useless. It is always the starting-point of an inductive inquiry and is of great help in the first stages of induction.

4. **Scientific Induction.**—A conclusion arrived at by *simple enumeration* can never be perfectly certain, unless we further attempt to establish a causal connexion; and when that is done, we have Scientific Induction. Mere enumeration may give us an idea of superficial connexion between things, hence its value is not much after all: but in Scientific Induction, which is the highest form of "Imperfect" Induction, we seek after some real connexion. It goes beyond factual relation established on the strength of mere enumeration, and aims at establishing a universal law whose validity may be independent of the citation of instances. Thus, if we know that certain men died, we may attempt to understand the reason why as men they died. If we understand that mortality is one of the attributes of humanity, we may at once state with confidence that 'All men are

[1] cf. "It can do no more than verify a 'that'. It cannot verify a 'how'. Given the observed fact that p, q are, in a certain number of cases, accompanied by x, the induction at best can only verify the suggested *fact* that p, q are in all possible instances accompanied by x".—Boyce Gibson, *op cit.* p 356.

mortal'. The certainty of this proposition follows more from establishing a causal relation between 'humanity' and 'mortality' than from the factual relation based on the simple enumeration of one or more cases.[1] Scientific Induction, therefore, claims to give us 'certain' knowledge. Only *one* case, if thoroughly analysed, is sufficient to warrant the truth of a universal proposition. True scientific explanation, which is based on the discovery of the laws of causal connexion, is only possible through this type of Induction. While Induction by Simple Enumeration merely states a fact of uniform connexion but fails to deal with *apparent exceptions* to a generalisation, Scientific Induction overcomes the difficulty by attempting by a thoroughgoing *analysis* to establish a universal law of *causal connexion*. This brings out the proper function of Scientific Induction: it is to explain the *how* and not merely the *that* of phenomena.

The essential steps in Scientific Induction are:—

(*i*) Preliminary observation of facts.

(*ii*) Supposition as to their cause.

(*iii*) Verification of the hypothesis.

(*iv*) Explanation of the law.

(*v*) Application of the established law.

The remaining types of Induction are discussed in the following Chapter, where a complete scheme of Induction is outlined.

[1] 'The name Scientific Induction is something of a contradiction in terms. Induction *is meant to mean* the treatment of instances. Scientific analysis as such, however, does not deal with instances, but only with contents. When we speak of a scientific treatment of instances, we mean a precise determination and skilful resolution of their contents.' Bosanquet, *Logic* II. ch. IV.

SUMMARY

An induction is said to be "Perfect" when *all* the instances coming under the supposed rule have been examined and found to be truly cases of it. It requires *complete enumeration* of the instances covered by a rule. According to Aristotle, Perfect Induction is the only "formally valid" induction; while according to Mill this process is merely a shorthand registration of facts known and cannot be called induction. It is not an inference from facts known to facts unknown but merely the summing up of known facts.

An induction is said to be "Imperfect" when only a few instances are examined. It rests on the assumption of similarity between the examined and the unexamined cases.

There are two principal kinds of Imperfect Induction. (*i*) Induction by Simple Enumeration and (*ii*) Scientific Induction.

Induction by Simple Enumeration consists in establishing a universal truth on the ground of *mere enumeration* of instances, without any attempt at causal explanation, It differs from Perfect Induction (based on *complete* enumeration) in that its conclusion is not a mere summing up of the known facts but is much more general. This type of induction is based on the principle that the future will *probably* resemble the past. Thus it ends in *probability* and not *certainty*. It can only state a fact of uniform connexion but cannot establish any causal connexion. It merely explains the 'that' and not the 'how' of phenomena.

Scientific Induction undertakes to discover principles of universal connexion through the analysis and comparison of instances. Sometimes even a single instance

is enough to establish a causal relation; all depends on the completeness and adequacy of our analysis. The proper function of Scientific Induction is to explain the 'how' and not merely the 'that' of phenomena. The statement of the fact of a uniform connexion is not enough for purposes of science. That connexion itself must be explained.

Questions and Exercises

1. Distinguish between Perfect and Imperfect Induction, and consider the value of the distinction.

2. What efficacy was attributed to induction by complete enumeration ("Perfect Induction") by Aristotle?

3. State very briefly Mill's criticism of "Perfect Induction".

4. How far and in what sense is it true to speak of the superiority of "Imperfect" over "Perfect" Induction?

5. Discuss the relative worth of Induction by Simple Enumeration and Induction by Complete Enumeration.

6. State the chief limitations of *Inductio per Enumerationem Simplicem.*

7. Explain the distinction between Induction by Enumeration and Induction by analysis.

8. Wherein lies the essential value of Scientific Induction?

9. What is the aim of Scientific Induction and how does it seek to realise it?

10. Explain and discuss the doctrine that induction is based upon the theory of probability.

11. Explain and illustrate the following statement:—"Logical induction concludes from *each one* to *all*: induction properly so called concerns the matter of thought, and concludes from *some* to *all*."—*Bowen*.

12. Is it possible to arrive at a universal proposition without actually observing all the individuals denoted by the subject of the proposition? If so, how?

CHAPTER III

MILL'S INDUCTIVE SCHEME

1. **Scheme of Inductive Inferences.**—In Book III of his *System of Logic* Mill gives a detailed account of Inductive Inferences. He first distinguishes "Inductions properly so called" from "Inductions improperly so called." Unless there is an inference, *i.e.*, unless we proceed from the known to the unknown, there is no induction. Hence all those processes in which this characteristic is wanting are to be put aside. Mill mentions three of these, *viz.* (1) Perfect Induction (2) Parity of Reasoning, and (3) Colligation of Facts. All these are types of Inductions improperly so called. Under the head of Inductions properly so called, Mill reckons two types, *viz.* (1) Imperfect Inductions, and (2) Scientific Induction. The former has again two forms; (*i*) Imperfect Enumeration, and (*ii*) Analogy. The complete scheme may be drawn up as follows:—

Inductions.

- **Improperly so called.**
  - **Perfect Induction.**
  - **Parity of Reasoning.**
  - **Colligation of Facts.**
- **Properly so called.**
  - **Imperfect Inductions.**
    - **Imperfect Enumeration.**
    - **Analogy.**
  - **Scientific Induction.**

Under the head 'Inductions improperly so called' Mill puts the three processes which cannot be called Induction in the true sense. Induction is generalisation from experience. It "consists in drawing inferences from known cases to unknown",..."in inferring from some individual instances in which a phenomenon is observed to occur, that it occurs in all instances of a certain class; namely, in all which *resemble* the former, in what are regarded as the material circumstances." All those processes, therefore, in which there is no progress to facts unknown or in which the general truth obtained is not believed on the evidence of particular instances, are not to be given the title of Induction. We might then consider the three types put by Mill under the head 'Inductions improperly so called.'

2. **Perfect Induction.**—This has already been described as that process in which we infer a general proposition after examining all the individuals that go to form the class. For instance: there are ten teachers on the staff of a school; we find that each has a faulty pronunciation, and infer that the school fails to teach correct pronunciation. Again, if a family consists of five girls and three boys, and none of them is married, we infer that all members of that family are unmarried. According to Mill, the characteristic quality of Induction is wanting in such inferences, since there is no transition from the known to the unknown. It is nothing more than 'a mere shorthand registration of facts known' and cannot be called induction in any sense of the word.

3. **Parity of Reasoning.**—This is another type of reasoning, used in Mathematics, which bears a certain resemblance to induction but lacks in its characteristic quality. For instance, we examine a particular triangle A B C and find that the sum of its two angles is greater

than the third angle; then we assert the same of *all triangles*. The generalisation in this case is not based on the particular fact about the triangle A B C but on the *same reason* which convinced us of this truth in the case of A B C. This process is known as 'Induction by Parity of Reasoning'. Mill puts it aside as an *apparent* induction for the simple reason that even though we arrive at a universal conclusion, we examine only *one* instance, and the truth of the conclusion is not grounded in the evidence of the particular instance but in the *reason* which guided us to the discovery of the truth in that one case. Parity of Reasoning is, therefore, not essentially different from Identity of Reasoning, which does not involve any transition from the known to the unknown facts. The difference between Induction and Mathematical Reasoning rests on the character of the evidence.[1] In Induction, we examine x, y, z, etc., and discover a common property of each, but our knowledge of the unexamined individuals is not such as to enable us to say that they *must* have this property. But in Mathematical Reasoning our knowledge of the common property of x, y, z, etc rests on definition and demonstration, not on any inductive leap. In the former, the evidence is *a posteriori*, in the latter *a priori*.

To sum up: Mill would not allow certain mathematical generalisations—in which we argue by *parity of reasoning*—to be classed as Inductions Proper. In them "the characteristic quality of Induction is wanting, since the truth obtained, though really general, is not believed on the evidence of particular instances" (Mill).

4. **Colligation of Facts.**—This term, originally used by Whewell, means 'the act of bringing a number of

[1] cf. Croke, *Logic*, London, 1906, pp. 246 ff.

facts actually observed under a general description': *e.g.*, we gradually discover an island to be an island by sailing all round it. Kepler's discovery of the orbit of Mars furnishes another typical example. He could not possibly observe its progress continuously, so he noted down a number of observations on its successive positions and guessed that the line joining these points would make an ellipse.

Whewell maintains, while Mill denies, that Colligation is Induction.

Mill's View :—Colligation of facts is a mere description of a set of observed phenomena, and must not be confounded with Induction. It may be looked upon as a process subsidiary to Induction but not identical with it. Whewell is "mistaken in setting up this kind of operation, which according to the old and received meaning of the term is not induction at all, as the type of Induction generally; and laying down throughout his work, as principles of Induction, the principles of mere colligation". The scientific study of facts may be undertaken for three different purposes, *viz.*, (*i*) their simple description, (*ii*) their explanation, (*iii*) their prediction—*i.e.*, the determination of the conditions under which similar facts may be expected again to occur. According to Mill, only the first of these three operations may be called *Colligation*, but it is not *Induction*: the name Induction properly belongs to the other two operations.

Whewell's Defence :—Colligation is more than a mere summation of facts, since it introduces a principle of connexion, which is to be derived from the mind and not from the facts as such. Kepler's statement about the elliptical orbit of Mars 'was not the sum of the observations merely: it was the sum of the observations *seen under a new point of view*, which point of view

Kepler's mind supplied'. Had it been a mere summary of facts, it could have been arrived at by adding together the different observations.

Criticism :—Both views contain partial truth. Colligation is certainly more than a mere summary of facts : so far Whewell is right. But, at the same time, Mill is right in disallowing it the title of Induction. It is indeed a generalisation, but not yet verified or universalised. Induction involves not only colligation but also an appropriate test of proof. Thus, Colligation is one of the stages in the process of Induction. Every induction could be viewed as a colligation of facts but every colligation of *facts, is not* an induction. Induction aims at causal explanation, while colligation does not go beyond describing a set of observed phenomena in general terms. Colligation cannot, therefore, be identified with Induction.

5. **Induction Proper.**—Now we come to the second main head, *viz.*, Inductions properly so called, under which Mill places (1) Imperfect Inductions and (2) Scientific Induction. The latter has already been considered in the last Chapter. The former has two forms, (*a*) Imperfect Enumeration. which is the same as Induction by Simple Enumeration, also discussed above, and (*b*) Analogy, which we now proceed to explain.

6. **Analogy.**—Argument from Analogy originally meant (in Aristotle), 'an equality or identity of ratios'. 'Thus, if we infer from the relation $a : b : : c : d$ that what is true of the relation between a and b will also be true of that between c and d, we are said to argue from analogy : *e g.*—As the parents are to their children, so is the Government to its subjects; hence, as children must obey their parents, the subjects must also obey their Government. So we may argue—

As flame : fuel : : light : flame,

∴ As the flame dies out with the fuel, so does the light with the flame. (Stock).

But the modern sense of the term is 'an inference based on resemblance or similarity between two things'. The form of the argument is—

Two things A and B resemble in one or more properties, x, y, . . .

B possesses a certain other property P.

∴ A also possesses the property P.

In other words, if two things resemble each other in several respects, they will also resemble in one point more.[1] We do not count instances here, but we analyse the character and weigh the properties of the particular instances observed. We know that bare identities or bare differences are mere abstractions; and that when we compare any two objects they can never be completely identical or totally different. There must be resemblances as well as differences—and Analogy picks out the points of resemblance. Its value, therefore, rests on the importance of the resemblances, and it is necessary that such resemblances should be *essential*. Thus we use the Analogical argument when, for instance, we say: The Earth and Mars resemble in several important respects, *e.g.*, in atmospheric and temperature conditions; therefore, they will also resemble in another respect, *viz.*, habitability, *i.e.*, as the Earth is inhabited, Mars should also be inhabited.

Mill rightly insists on the importance of weighing rather than counting the points of resemblance between any two objects. He says—

"Since the value of an analogical argument, inferring

[1] Analogy is "resemblance of relations" (Whately); it is "the similarity of ration or relations" (Thomson).

one resemblance from other resemblances without any antecedent evidence of a connexion between them, depends on the extent of ascertained resemblance, compared first with the amount of ascertained difference, and next with the extent of the unexplored region of unascertained properties; it follows that . . . if after much observation of B, we find that it agrees with A in nine out of ten of its known properties, we may conclude with a probability of nine to one that it will possess any given derivative property of A."[1]

The number of resemblances is not so important as the reasons which lead us to connect the resemblances with the property in question. Without such reasons Analogy is no better than guess-work. Its cogency depends on our ability to show that the *fundamentum relationis*, the circumstance common to the two cases, is the material circumstance, and that on it depend the rest of the circumstances.[2] Analogy cannot be a conclusive argument unless verified by scientific Experiment. It is not *proof*; many conclusions are verified but many are also rejected as false.[3] By itself it can only yield *probability* rather than *certainty*, unless a causal connexion can be established between the common qualities of the two objects compared. The Earth has, for instance, several resemblances with the Moon; but, as Mill shows, a single essential difference, *viz*, the absence of atmosphere in the moon, is enough to set aside those resemblances, and we cannot, therefore, infer the habitability of the moon. When even one important difference is observed "all the resemblances which exist become presumptions against, not in favour of, the moon's being inhabited"

[1] cf. Mill, *A System of Logic*, Bk III. ch. 20 sect. 3.

[2] cf. Croke, *op. cit.* p. 249 *note*.

[3] cf. Lotze, *Logik*. sect 214.

(Mill). There is, therefore, no evidence to show, as has been supposed by several critics, that Mill based Analogy on a mere enumeration of resemblances.

Analogy cannot take the place of complete Induction. Where the latter is attainable, analogy should only be treated as a process through which further suggestions for the establishment of scientific laws are obtainable. As Mill said, analogy has the highest scientific value when it is used as 'a mere guide-post, pointing out the direction in which more rigorous investigations should be prosecuted'. Boyce Gibson has rightly pointed out that the true place of Analogy is in the service of Scientific Induction. "In relation to a complete scientific inquiry its logical function is heuristic. It plays an important part in the Logic of Discovery, but has no place in the Logic of Verification"[1] It is never complete proof but a stage on the road to exact knowledge or demonstration. It does operate in Induction, and becomes Induction when 'fortified by negative and precise determination'. This leads us, by the way, to institute a comparison between Analogy and Induction to see how far the former shares the latter's characteristics,[2]—

Induction	Analogy
1. *Principle*: What belongs to many individuals of a species probably belongs to all the rest of that class.	1. *Principle*: If two things agree in many respects, they probably agree in some other respect as well.
2. Procedure by way of extension.	2 Procedure by way of intension

[1] *Op. cit. p.* 361.

[2] On this point refer to Bowen's *Logic*, p. 381 ; also Croke's *Logic. p*, 249.

Induction	Analogy
3. Based on comparison, elimination and generalisation.	3. Based on resemblance discovered by comparison.
4. Reasoning from one in many to one in all.	4. Reasoning from some in two to some more in two.
5. We conclude from many things to all others of the same species.	5. We conclude from the known agreement of two things in several qualities their agreement also in some other quality not directly known.
6. Quality *p* exists in *a*, *b*, *c*, etc. ∴ *p*, exists in the whole class constituted by *a*, *b*, *c*, etc.	6. *a* and *b* agree in possessing the common qualities *p*, *q*, *r*, etc. ∴ they also possess the further quality *s*.
7. We argue from Particular to Universal.	7. *Explicitly* we argue from Particular to Particular, but *implicitly* from Particular to Universal.

Thus, it is clear that Analogy cannot be identified with Induction. It is only one of the accessories of Induction: and, although we speak of Inductive Inference by Analogy, we must carefully note its peculiarities and limitations.

Many analogical arguments are usually couched in metaphorical language, and it is found that their unsoundness is sometimes due to the use of metaphor. While on the one hand, analogy is, as a rule, very convincing, it is, on the other hand, often misleading. We have cases of *False Analogy*, [1] whenever we argue from certain resemblances to certain others, which are neither essential nor important. The following may be taken as *typical examples* :—

[1] 'The term False Analogy is applied only to those cases of analogical inference in which there exists no ground whatever for any analogy (*vide* Fowler, *Inductive Logic*, Ch. VI.)

(1). On account of his exceptional bravery, Ranjit Singh was known as "the Lion of the Punjab". Therefore, he could also roar like the lion.

(2). Daisy and Stella resemble each other in physical features. Daisy is an expert in cookery and needlework. Therefore, Stella is also a good cook and a good needlewoman.

(3). A and B resemble each other in possessing skill in witchcraft. A is further addicted to opium-eating. Therefore B is also an opium-eater.

(4). A and B are logicians of great reputation. They resemble each other in possessing an extraordinary skill in dialectic disputation. But A never sleeps before midnight. Therefore B also never sleeps before midnight.

(5). States are, like individuals, subject to decay. (Mill says: "Bodies politic die, but it is of disease or violent death; they have no old age.")

(6). A and B are millionaires. But A is a robber. Therefore B is also a robber.

It is truly said, that 'analogy never walks on four legs.' We must always note the essential points of resemblance, *viz.*, those which constitute the *fundamentum relationis*. If a doctrine is accepted as true, sometimes people draw from it conclusions which have not the remotest connexion with it. All that leads to False Analogy.

In its modern sense, Analogy is sometimes known as *Example*. An Example is 'an argument which proves something to be true in a particular case from another particular case.' Aristotle calls it "oratorical induction", since it is so frequently made use of by orators in order

to add to the effect of their speech. Analogy, however, may proceed from one class to another on the basis of resemblance, but Example always argues from one particular or individual case to another such case.

SUMMARY

A complete scheme of Inductive inferences may be drawn up, after Mill, as follows:—

I. Inductions *improperly* so called:—

(1) Perfect Induction:—Consists in examining all *possible* cases before arriving at a generalisation. Here there is no transition to the unknown cases, but only a summing up of all the known cases. Hence it is not Induction in the true sense. *Vide* Ch. II *supra.*

(2) Parity of Reasoning,—This is also an apparent induction, like the first. Although we arrive at a universal conclusion, we examine only *one* instance, and the truth of the conclusion is grounded in the *reason* which guided us to the discovery of the truth in that one case. Mathematical reasoning, as a rule, proceeds by Parity of Reasoning.

(3) Colligation of Facts.—Like the other two, this is also a kind of Quasi-Induction. Whewell maintains, while Mill denies, that it is Induction. It is a generalisation, but not yet verified or universalised. Hence it cannot be identified with Induction. At the same time, it is not a mere summary of facts. It is one of the stages in the process of Induction. Every Induction involves Colligation, but every Colligation is not Induction.

II. Inductions *properly* so called,—

(1) Imperfect Inductions: rest on assumed similarity between the examined and the unexamined cases. Two forms,—

(i) Inductio per enumerationem simplicem, *i.e.* induction which rests on *imperfect enumeration.* This kind of induction exhausts all *known* cases (not all *possible* cases, as in "Perfect" induction) *Vide* Ch. II *supra.*

(ii) Analogy.—Argument from Analogy assumes similarity between two things. It rests on the principle that if two things agree in many respects, they probably agree in some other respect as well. It is more important to weigh the points of resemblance than *merely* to count them. The conclusion from Analogy can only be *probable*, not *certain*. The fallacy of False Analogy arises when we suppose that resemblance in some points is an evidence of that in other points, when actually there is no connexion between the observed and the unobserved points,

(2) Scientific Induction.—In Science it is generally impossible to examine all possible cases. Even a single case, thoroughly analysed, may reveal a causal relation. Scientific Induction is not satisfied with establishing a uniform connexion between phenomena, but proposes to enter into the *how* by seeking a causal relation between them. It is the highest form of Induction and is conducted by a thoroughgoing analysis of instances—sometimes of a single instance.

Questions and Exercises

1. Sketch a complete scheme of Inductive Inferences.

2. Name and exemplify Inductions improperly so called.

3. Define Perfect Induction. In what type of syllogism is it represented ?

4. Examine the truth of the following statement—"Perfect Induction is demonstrative and syllogistic : Imperfect Induction is neither."

5. How does Geometrical reasoning differ from Induction ? Does it possess any resemblance to Induction ?

6. What do you understand by the expression "Parity of reasoning ?" Give an example.

7. Give Whewell's account of 'Colligation of Facts.' Also state Mill's criticism of Whewell.

8. Is Colligation more than a description in general terms of a set of observed phenomena ?

9. Would you identify Colligation with Induction or distinguish the two ? Give reasons for your answer.

10. State the distinctive characteristic of Induction according to Mill, and name the forms of Quasi-Induction or Apparent Induction you know of.

11. What is Argument from Analogy ? How does it differ from Induction and how from metaphorical argument ?

12. On what does the cogency of an argument from analogy depend ?

13. Distinguish between Analogy and Induction.

14. Give typical examples of Induction and Analogy.

15. Is the analogical argument syllogistic ? Give reasons for your answer.

16. Examine the truth of the following statements :—
    (a) Induction is imperfect analogy.
    (b) Analogy is imperfect induction.
    (c) Analogy is incomplete explanation.

17. If all analogical reasoning yields only probability, is not one analogy as good as another for purposes of inference? If not, upon what does its *value* depend?

18. Explain the fallacy of False Analogy.

19. Discuss :—"Analogy, the most valuable of instruments in the maturity of jurisprudence, is the most dangerous of snares in its infancy" (Maine).

20. Criticise the following argument :—"There are probably inhabitants in the moon, because there are inhabitants on the earth, in the sea and in the air."

CHAPTER IV

PRESUPPOSITIONS OF INDUCTION

1. **Grounds of Induction.**— Induction is based on generalisation. Unless we generalise on the evidence of particular facts examined, there is no induction. Hence the justification for generalisation furnishes the grounds of induction. Such justification lies in our belief in reality as a systematic unity of inter-related parts. Nature is one vast organism, in which the functions of each part are determined by the requirements of the Whole. If Nature were not a systematic unity the sun that rose yesterday and to-day may possibly not rise to-morrow; men who walk on their legs to-day may begin to walk on their heads to-morrow; fire that burns to-day may become cold henceforth; stones that are seen to fall down when thrown up may change their mood and begin to behave otherwise;—in fact, there would then be no guarantee why the future should resemble the past; no knowledge would be possible; even life itself would become impossible.

We have, therefore, to assume that our experience is an organised whole, that Nature is not an inchoate heap of phenomena but an inter-related and coherent totality. Hence the most general principle which lies at the root of all induction is that of Sufficient Reason, which postulates that reality is intelligible and can

therefore be explained (to a certain extent). 'There is no difference without its reason.'[1] Every inquiry into the problem of Truth is based on this assumption. The principle may be stated as—"All change must have a sufficient reason" or "Every fact that happens must have a sufficient reason." This principle is *formal* as well as *real*, and may, therefore, be enunciated as follows :—

Formal : "Whatever is *judged* to be true must have a reason in our *thought* for being so judged," and

Real : "Whatever happens in the actual order of being must have a sufficient reason for so happening."

We are now concerned with the *real* aspect of the Principle. Reality is such that everything that happens in it must have a sufficient reason. When this principle is applied to the phenomena of Nature it assumes the more concrete form in the *Principle of Causality*, which says that 'every event has a cause.' A further corollary from the Law of Causality is the Law of Uniformity of Causation, also known as the Uniformity of Nature, *viz.*, 'the same cause has the same effect.'

Thus, although the Principle of Sufficient Reason is ultimately the basis of Induction, it is rather too wide in its application. When applied to Nature it becomes the Principle of Causality, which should, therefore, be accepted as the ultimate presupposition or postulate of Induction.

While many logicians (*cf.* Mill, Bain, Carveth Read, Welton, Croke, etc.) take the Principle of Uniformity of

[1] This is illustrated in Lotze's formula 'A + B = C,' which means that the subject A can only pass into a specific phase C under an assignable condition B. The Law of Sufficient Reason "represents the demand of intelligence for the explanation of everything by something else." (Bosanquet, *op. cit.* I. Ch. VII).

Nature as the ultimate ground of Induction, and view Causation as only *one* kind of uniformity, *viz.*, that of sequence; we, on the other hand, hold that Causation is the ultimate presupposition of Induction and that the Law of Uniformity (as also Reciprocity of Cause and Effect) is already implied and included in Causation. Since a *cause* cannot be so called, unless its effect follows from it *always* under like conditions.[1] If the effect follows *sometimes* and does not follow at other times, its so-called cause has no title to be regarded as *Cause*. Joseph and Mellone, among a few others, share this view of ours. The following scheme shows the principle of Causation as the foundation of Induction and its relation to the other principles:—

Induction is grounded in

Law of Causation

"Every phenomenon has a cause."

A concrete form of
Law of **Sufficient Reason**:
"Everything has a sufficient reason for its being."

Includes
(1) Law of **Uniformity of Nature**:
(Uniformity of Causation):
"The same cause must have the same effect," and its converse
(2) The **Reciprocity of Cause and Effect**:
"Every effect always has the same cause."

[1] Our view can easily be reconciled with our mataphysical doctrine of the inherent indentity of Cause and Effect. If we confine Causation (in Logic) merely to sequence in time or succession we find no way to agree with the doctrine of the identity of Cause and Effect. In Hindu Logic the two theories known as Asatkāryavada and Satkāryavāda are worked out side by side. *Vide* § 15 below.

Induction is chiefly concerned with the discovery of *causes* of phenomena, and we shall therefore inquire into the meaning and implication of the principle of Causation at some length. The typical representative of the Empirical school is J. S. Mill; hence, before proceeding further we must review his teaching.

2. **Mill's View of Causation.**—Mill is careful enough to preface his inquiry into the Law of Causation by the remark that he speaks of *physical* causes only, and not of *efficient* causes, that he does not propose to go into "the ultimate or ontological cause of anything." Excluding the notion of efficiency in causes, he defines *cause* as invariable and unconditional sequence. If A is invariably and unconditionally followed by B, it means that A is the *cause* of B. Causation is a Uniformity—the uniformity of *succession*—the other uniformity being that of *co-existence*, under which Mill classes, *e.g.*, the laws of number and of geometry, in fact, all generalisations in which any two qualities A and B are found to be inseparable, although we fail to explain their co-existence.

Causation is the law of the succession of phenomena. "The Law of Causation," says Mill,[1] "the recognition of which is the main pillar of inductive science, is but the familiar truth, that invariability of succession is found by observation to obtain between every fact in nature and some other fact which has preceded." In the section following, he continues: "The cause is the sum-total of the conditions positive and negative taken together: the whole of the contingencies of every description, which being realised, the consequent invariably follows." Here we have the antecedent conditions and the consequent event distinguished. The former taken together are called the *cause* the latter the *effect*. The negative

[1] cf. Book III, ii. 2.

conditions are summed up by Mill under one head, viz., "the absence of preventing or counteracting causes." Thus the cause of a phenomenon is constituted by the group of antecedents, which being realised, the phenomenon follows.

Now, if causation were merely *invariable sequence* and nothing more, day would be called the "cause" of night, since it is invariably followed by night; similarly night could be called the "cause" of day for the same reason. Hence, causal sequence is more than mere invariable succession. It must also be "*unconditional*," hence, Mill gives his final and "scientific" definition of "cause" as follows:—"We may define, therefore, the cause of a phenomenon, to be the antecedent, or the concurrence of antecedents, on which it is *invariably* and *unconditionally* consequent." Thus the succession of day and night cannot be called 'causal,' since, although *invariable,* it is not *unconditional*. It is determined by the occurrence of other antecedents.

The ordinary and popular view of CAUSE is anything in the absence of which a phenomenon would not come to pass, and the tendency is to select the *proximate* antecedent and give the name 'cause' to that alone. This view is recognised in Mill's own account, but at the same time he improves it by his scientific view, which takes cause as the *whole group* or the *sum-total* of conditions, positive and negative. The latter view is usually regarded as incongruous with the former but to us it seems to be only a little more cautious and exact statement.

3. **Criticism of Mill's Doctrine.**—Various lines of argument have been advanced against Mill's account of causation. The following are the chief points for criticism:—

(1.) Joyce finds fault with Mill's doctrine on the

ground that the reduction of efficient causality to a mere time-relation is totally contrary to reason. Everything which comes into being must have not a mere antecedent in time, but an efficient cause which is the reason why it exists.[1]

But this criticism appears to us beside the point. Mill expressly tells us that he is not discussing the ontology or metaphysics of causality, and by 'cause' he means *physical* and not *efficient* cause. Joyce simply preaches the metaphysics of causality to a logician who is dealing with the relation of natural phenomena. The following point would, therefore, be more relevant in criticism of Mill :

(2.) If causality is mere succession in time, Mill cannot with any justification speak of the *unconditional* character of the connexion. We can only speak of B following A, and not as to *how* the causal tie between A and B exists. But unless we know something about the *how*, the *reason* why B must follow A, we cannot speak of A as the *unconditional* antecedent of B. To know it we have to transcend the mere sequence of phenomena in time.

(3.) In defining cause as the sum-total of positive and negative *conditions* indispensible for the production of the effect, Mill wrongly identifies cause with 'conditions.' *Cause* must be distinguished from *condition.*[2]

[1] cf. Joyce, *Principles of Logic*, 1908, p. 242.

[2] "A *cause* is that which makes a thing to be what it is, while a *condition* is that which in one way or another enables the causes to act in the production of the effect, but which does not make the thing what it is" (Joyce, p. 220). A *condition*, although *necessary* for the production of the effect, does not *positively* contribute thereto. For instance, powder must be dry in order that it may have its effect in gunshot ; or, again, to allow daylight in a room there must be some windows. In either case we have a condition, not the cause.

(4.) As an empiricist Mill cannot believe in 'necessary connexion', yet he defines 'cause' as an *invariable* antecedent. "'Invariable' means 'that which *cannot* vary', and empiricism means that we are not to speculate in advance of the facts: how, then, can it have cognizance of more than an observed absence of variation, and how can it infer an absence of a 'power' it had declared to be an illusion? Clearly the transition from 'unvaried' to 'invariable' is beyond its power" [1]

(5.) Mill's phrase "sum-total of conditions" is misleading. (*i*) It indicates a special way, which may be inappropriate, of combining the factors. 'The totality of the relations' would be a better phrase than 'the sum of the conditions' (Bosanquet). (*ii*) It is not clear whether it is limited to *relevant* conditions or not. If it is, it becomes quite incompatible with Mill's doctrine of the Plurality of Causes, (*viz.*, that an effect may be produced by *many* causes). If, however, the phrase is not limited to relevant causes, it may be compatible with 'Plurality of Causes', but it loses its real meaning and thereby confuses 'cause' and 'condition.' There would then be no analysis: it would be meaningless tautology to speak of 'cause' and 'effect.'

(5.) The notion of cause implies efficiency, which even Mill—so careful to avoid *efficient causes*—has to admit in speaking of the *unconditional* character of the causal connexion. Moreover, such unconditionality cannot be proved in the case of physical phenomena.[2]

(6.) The idea of cause as an event in time prior to the effect, *i.e.*, the time-sequence of causation, is

[1] Schiller, *op. cit.* p. 288.

[2] cf. "Mill sets out by discarding 'efficient' causes, and yet he finds cause in a set of conditions whose existence necessitates that of the effect; greater efficiency than this no one would wish to establish."—Welton, *op. cit*, II., p. 19.

unsound. As this is of particular importance, we shall discuss it in the following section.

4. **Causation as Sequence in Time** : *Criticised*, Mill's doctrine contains the erroneous implication that *time-sequence* is an essential character of causation. This seems to be due to the natural tendency of translating distinctions in thought into separations in fact. Mill speaks of the antecedent as 'cause,' and the consequent as 'effect,' but the statement is false, if taken seriously. Causality is a process, it is a change, and there is no stage at which we could say that the cause has ceased, and the effect has begun.[1] The immediate cause co-exists with the immediate effect. The process of real change is one, and if the cause ceases to act, the effect also ceases to be produced. Change does take place *in time*, but it is one continuous process and its moments are not separated *by time*. In other words, cause and effect are not divided by time, in the sense of duration, or lapse, or interspace: they are separated *in* time by an ideal line which we draw across the indivisible process.[2] Mellone rightly observes: "Cause and effect are divided by a simple mathematical line—a line destitute of breadth—which is thrown by our thought across the current of events; on one side we have the cause, on the other the effect. There is no pause in reality;

[1] One might refer to a case in which a man takes poison now, and the result death comes long after. But it would be wrong to argue that between the taking of poison and the occurrence of death nothing has happened. In fact the poison begins to act as soon as it is taken, cause and effect co-exist, and it is only one of the last links in the long chain of events that we call death. Poison goes on acting, each stage is imperceptibly linked up with the following and it is quite arbitrary to take no notice of the many proximate causes of death lying between the taking of poison and the event of death.

[2] cf. Croke, *op. cit.* p. 311.

the whole process is continuous; the immediate cause comes into full action only at the very moment when the effect begins to be produced. The point, to be borne in mind is the *continuity* of cause and effect."[1] Causation is, therefore, 'something that is not in succession, though it remains through succession'. Mill is aware of discreteness only, he is blind to the continuity of the process. "Cause as an event in time," says Bosanquet, "is an imperfect conception. Indeed it is hardly possible to formulate the idea of one event in time, as the cause of another that falls, in time, wholly outside the first. Cause is always taken to be more or less of a complication of relations and circumstances; and these as acknowledged to bear on one another, are not mere events in time."[2]

5. **Our View of Causation.**—Criticism of the empirical theory of causation leads us now to state our own view in brief. It seems to us that Mill's account of cause as the invariable and unconditional *antecedent* states only half the truth, and taken by itself it cannot be accepted as a complete theory. Mere succession, as we have already observed, explains nothing. The effect may follow the cause unvariedly, but on strictly empirical data we cannot predict the future. The senses do not reveal any real connexion between two phenomena known as *cause* and *effect*. They give us only a stream of perceptions, and from the empirical standpoint we have no right to assume the existence of any *necessary connexion* between them. On this point Hume (1711-1776), who

[1] S. H. Mellone, *op. cit.* p. 273. cf. Bradley, *Principles of Logic*, p. 488.

[2] Logic I, ch. VI. "The temporal succession, which seems the natural differentia of causation, disappears in the reference of the effect to a positive and continuous system. Mere temporal relation is negative, is nothing. It is only the unity behind the temporal relation that can bind cause to its effect."—*ibid*

pointed out the bankruptcy of empiricism, was unanswerable. His position may be summed up very briefly as follows :—

The idea of causility has a purely subjective significance. The necessary connexion which we postulate between cause and effect can neither be demonstrated nor felt. It is not true to say that the idea of causality can be derived from experience ; since experience only gives us a mere succession of sensations, a mere sequence of isolated events without any interconnexion. "We have no idea of connexion or power at all, and these words are absolutely without any meaning." Causation is nothing more than customary succession. By themselves all events are loose and separate. They seem *conjoined* but never *connected*. From the mere repetition of any past impression even to infinity, there will never arise the idea of necessary connexion. It is in our own mind and we erroneously project it outwards and thereby create an illusion.

All this goes to prove that on the basis of *experience* we can only speak of the mere *sequence* of two phenomena. But causation implies much more than mere succession in time.

The idealistic theory, on the other hand, also goes to the other extreme and is blind to half the truth. In its anxiety to state the truth from the metaphysical standpoint it ignores the logical distinctions of cause and effect due to succession in time. It declares causation to be co-existence, not sequence. Cause and effect are viewed as merely two aspects of the same process. They are also pronounced to be identical in their essential nature. When they are referred to a complete system, the idea of temporal succession disappears, and cause is identified with the complete ground or "the totality of

systematic relations which constitute its necessity" (Bosanquet). The idealistic theory rightly maintains that the temporal order of cause and effect should be treated as the expression of a plan or unity. "*Except* as the expression of such a unity," writes Bosanquet, "causation disappears; but *as* the expression of such a unity, the causal relation ceases to be in time, because the positive connexion between cause and effect being made manifest, the two are united in the complete ground" (*ibid*). Now, it is unquestionably true that the process is not chopped up into bits of phenomena succeeding one after the other. There are no breaks in the process. Causation is 'the ideal reconstruction of a *continuous* process of change' but such reconstruction is *in time*, and the *continuum* is not in any way broken by an ideal line that distinguishes cause and effect. As Bradley observes: "Between the coming together of the separate conditions and the beginning of the process, is no halt or interval. Cause and effect are not divided by time in the sense of duration or lapse or interspace. They are separated *in* time by an ideal line which we draw across the indivisible process. For if the cause remained for the fraction of a second, it might remain through an indefinite future."[1] It is, however, sometimes forgotten that although causation is an indivisible process, yet in order to speak of cause and effect an ideal line must be drawn separating the two *in time*.[2] If you refuse to allow that, the reference to a distinctionless and continuous process serves no purpose for us and is altogether meaningless. Therefore,

[1] Bradley, *op. cit* p. 488 note.

[2] cf. "Granted that time and sequence are continuous, yet they are also discrete. There is indeed no interval in which we can stand and say 'The cause is past and the effect is not begun.' But unquestionably we can make a stand at any point in the continuous

if the effect is to have a beginning, the cause must also have a beginning. To produce the effect it *becomes* a cause, and becoming is change *in time*. This truth is sometimes ignored while speaking of causation as co-existence.

Thus, the true view of causation is to regard it as a continuous process of change in time. Causation is co-existence, but as a cause cannot exist without producing its effect, we speak of the beginning of cause and effect, which implies their succession in time. It is, therefore, not wrong to say that the effect succeeds the cause. It should only be added that it does so *immediately*, without any halts or breaks. In this way, the continuity of the process is not affected, and at the same time we do no violence to the ordinary view of causation as temporal succession. We only explain the sense in which we can speak of temporal succession. In content, cause and effect co-exist, but in their form or manifestation in phenomena, there is time-sequence.[1] This seems to be the only way of bringing together the elements of truth in the two theories.

6. **Plurality of Causes: Mill's Doctrine.**—The term 'Plurality of Causes' was introduced by Mill, who wrote as follows:—"It is not true . . . that one effect must be connected with only one cause, or assemblage of conditions; that each phenomenon can be produced only in one way. There are often several independent modes in which the same phenomenon could have originated. One fact may be the consequent in several invariable sequences: it may follow with equal uniformity, any one of several antecedents, or collections of antecedents

sequence and say 'so much is (or has been) real, the rest is not yet real.' And what is not yet real cannot be the cause of what is or has been real. This appears to be the root of our whole conviction about cause and effect in time." Bosanquet, *Logic*, I. ch. VI.

[1] cf. Welton, *op. cit*, II. p. 25 also.

(III x. 1). Thus, according to this doctrine, although the same cause, under similar circumstances, always produces the same effect, nevertheless, it is not true to say that the same effect is always due to the same cause. Many causes may bring about a certain effect. To take Mill's own example: death may be caused in several ways. We cannot speak of the "invariable antecedent" of death. It maybe due to one or more of a multitude of causes. It may, *e.g.*, be due to poisoning, plague, heart-failure, suffocation, suicide, shooting, smallpox, cholera, old age, etc. That the same effect may be produced by a plurality of causes is further shown by medical theory. The physician knows that a disease may be due to one or more of so many causes and he is anxious to determine *the cause* in each individual case he examines. Take Fainting or Syncope. There is no *one, fixed, invariable antecedent* to bring about this phenomenon. Thus Moore writes :—

"Fainting or Syncope occurs from *numerous causes.* It may result from *loss of blood*, or from *fright* or *sudden shock*; it may be produced by a blow over the stomach, or by intense pain; ... It may be caused by a disordered stomach, or may arise from certain diseases of the heart. It may even arise from great heat, or the vitiated air of crowded rooms; bad smells or unpleasant sounds." Thus—

Effect		*Plurality of Causes.*
	1	Loss of blood.
	2.	Fright.
	3.	Sudden shock.
	4.	Blow over the stomach.
	5.	Intense pain.
Fainting (due to) ...	6.	Disordered stomach.
	7.	Diseases of the heart.
	8.	Excessive heat.
	9.	Vitiated air.
	10.	Bad smells.
	11.	Unpleasant sounds.

These facts seem to support the doctrine of the Plurality of Causes. Mill concludes: "It is not true that the same phenomenon is always produced by the same cause, the effect *a* may sometimes arise from *A*, sometimes from *B*. . . . Many causes may produce motion; many causes may produce death" (*ibid*).

7. **Criticism of Mill's Doctrine.**—Mill took pains to distinguish the popular and the scientific meanings of the term 'cause', and finally defined 'cause' in the scientific sense as 'the invariable and unconditional antecedent of a phenomenon': yet, in emphasising his doctrine of the Plurality of Causes he either entirely overlooks this distinction and uses the term 'cause' in the popular sense or else expresses a view totally inconsistent with his own definition of cause. We must carefully distinguish the Plurality of Causes from the Composition of Causes, which means that a single complex phenomenon may have different causes acting together on one occasion. Such partial causes co-operate and jointly contribute to the production of the complex phenomenon, which we call one. For instance, a person's death may be brought about by a complication of diseases, of which no one could have singly proved fatal. In such cases, the term 'cause' is not given to any single 'partial' cause but to their composition. But the Plurality of Causes means that one and the same effect, *e.g.*, death, may on different occasions, be due to entirely different *total* causes, *e.g.*, poison, old age, explosion, etc.

But we hold that the same phenomenon cannot have different causes on different occasions. A cause, as defined in its scientific sense, would cease to be 'cause' if the same effect could have a plurality of causes. If, according to Mill himself, the essence of causation lies in 'invariable and unconditioned sequence', it means that

such sequence is independent of everything else, hence a certain sum-total of conditions can only produce just *one* effect, and that no two or more causes can ever bring about exactly the same effect.[1] Therefore, in this strict sense of the term 'cause', it is not true to say that a phenomenon may have a plurality of causes. The Plurality of Causes has only a semblance of reality: it is more apparent than real. As Joseph says: "the alternative 'causes' of a phenomenon, which make up the plurality, are none of them causes in the strictest sense, but rather events which agree so far as the production of the phenomenon requires, though taken as a whole they are very different."[2]

If the 'cause' is, in its strict sense, "the sum-total of the conditions, positive and negative, taken together", it is easy enough to see that the negative conditions --

[1] cf. "There are, as Mill observed, many causes of death; and though he was referring to men, it is also true of rats. But death is not the same thing whenever it occurs; and the doctor or the coroner knows this The many different causes of death do not altogether have the same effects; if you shoot a man and if you behead him, the difference in the result is visible; if you poleaxe an ox and if you poison him, he is not equally edible As soon as we begin to be interested in the particular variety of death produced, we find the number of causes that produce the result in which we are interested diminish rapidly; if we carried our interest far enough into detail, we might say that for death of a particular kind there was only one cause possible. But since much of this detail is quite unimportant, we treat as instances of the same event events which in some respects are different and then say that the same event has divers causes".—Joseph, *op. cit.* p. 447.

"There are many causes of death only because there are many kinds of death."—Mellone, *op cit.* p. 260.

"If only the effect is given in all its detail, there will never be more than one possible cause to account for it. The relation between Cause and Effect is thus, *ideally*, reciprocal or reversible" —B. Gibson, *op. cit.* p 384.

[2] Joseph, *op. cit.* p. 455.

which imply that 'nothing in the absence of which a phenomenon occurs can be its 'cause'—can never be fulfilled if the doctrine of the Plurality of Causes is also true. If one and the same effect can have different causes on different occasions, we cannot view 'cause' as that in the absence of which a phenomenon occurs'. It cannot be called 'cause' in the particular instance in which it is absent, but it may be on another occasion, when it is present. The relation between cause and effect is reciprocal: and as it is true to say that 'the same cause has the same effect', it is no less true to add 'the same effect has the same cause.'

At the same time we must bear in mind that the doctrine is true only if we use the term 'cause' in its popular sense; *i. e.*, not "the sum-total of positive and negative conditions," not "the invariable and unconditional antecedent" but 'conditions *sufficient* though not *indispensable*' for the production of an effect. In this sense, the same effect may be produced by different causes.[1]

Thus the doctrine of the Plurality of Causes is wholly incompatible with Mill's definition of 'cause' in its scientific or philosophic sense. If 'Cause' is merely the '*sum of conditions*' the Plurality of Causes is plausible, but if it is

[1] The doctrine holds good "as long as the 'cause' is understood in the popular way. *The plurality disappears before any exact scientific investigation.* The subtraction of any factor from the "total cause" in this strict scientific sense, or the addition of any new factor to it, must necessarily modify the effect: no other factors or combinations of factors could produce this sort of effect exactly and identically".—Coffey, *Science of Logic*, 1912, II, p. 86.

The wider conception of 'cause' which allows the 'plurality of causes' to hold good, is, however, "the most serviceable for purposes of inductive logic" (Venn, *Empirical Logic*, p. 71).

Properly speaking, to give the cause of anything is to give everything necessary, and nothing superfluous to its existence. But our practical aims cannot be satisfied by that much alone "What we want to know is not by any means always the recipro . ting cause of

defined in its sense as the '*sum of the conditions*,' there is nothing to support the doctrine. In this sense, as we said above, there is always a *reciprocity* between the cause and the effect.

8. **Cause Distinguished from Reason or Ground.**—We have spoken of the reciprocity of cause and effect. In this strictly philosophical sense, *cause* is identical with *ground*. We know that the hypothetical judgment, with its content composed of ground and consequent, is a reciprocal judgment, when ideally complete 'If A is B, it is C' is a hypothetical judgment. When it is ideally complete, we should be able to infer 'If A is C, it is B'. The relation is reciprocal, A cannot cohere with B, unless B coheres with A.[1]

Cause and Ground cannot, therefore, be distinguished in their perfect stage. The Cause is the Because. Complete Ground—which is ultimately not other than Real Ground—is identical with Cause as 'the sum of the

a determinate phenomenon : the phenomenon under investigation is often highly complex, and subject to all sorts of variation on the different occasions of its occurrence, through variation in the objects or events contributing to its production ; not the whole nature of the objects or events under whose influence it occurs is relevant to its occurrence, but only certain particular properties or modes of action".—Joseph, *op. cit.* p. 445.

"Sometimes what is practically most important is scientifically least important ; it may be of great importance to know what circumstances will produce an event without knowing *how* they produce it. For instance, it may be of importance to clear the premises of rats ; traps, strychnine, phosphorous and terriers are various 'causes' between which we must choose : but we do not as a rule hold post mortems on dead rats.' Mellone, *op. cit.* p 275.

[1] "The relation of Ground is thus essentially reciprocal, and it is only because the grounds alleged in everyday life are burdened with irrelevant matter or confused with causation in time that we consider the Hypothetical Judgment to be in its nature not reversible". "Complete Cause, like Complete Ground, corresponds to a Hypothetical Judgment, whose condition and consequent are reciprocal".—Bosanquet (*ibid*)

conditions.' In other words, as Cause and Ground are completed, they tend to coincide, "and the striking differences between them depend on a comparison of their imperfect and ultimately self-contradictory forms."[1] In their imperfect stage, cause is to be distinguished from ground. As such Cause is a species included in a common genus with the incomplete forms of Ground.

It is only by identifying Cause and Reason that the following paradox, referred to in the previous section, can be met: "What is merely essential to the effect is always something less than any combination of real "things" which will produce the effect, because every real thing has many properties irrelevant to this particular effect. So, *if the cause means something real*, as a material object is real, it cannot be invariable and essential. If it is not something real, and is essential, it fines down into a reason or law—the antecedent in a hypothetical judgment."[2]

Causation is known by reasoning. The cause, as we know it in its complete form, is always the Reason or Ground. But the Reason is not always the Cause of the consequence. As Bradley says, "In some cases, no doubt, it (the reason) does appear as the cause, but in others we cannot see how this is possible."[3] The cause, as we know it, is always a because; but every because does not appear as a cause.

Sometimes *Cause* and *Reason* are distinguished with reference to the order of reality and the order of thought respectively. Thus 'Cause' is said to be that on which something depends in the real order, and 'Reason' that

[1] Bosanquet (*ibid.*) "Ground and Cause are thus not co-ordinate but convergent conceptions."

[2] Bosanquet, *Essentials of Logic*, Macmillan, 1895 p. 165.

[3] Bradley, *op. cit.* p. 497.

on which something depends in the order of thought.[1] This distinction also explains that between *Causa Essendi*, the ground of existence, or that which explains why a change is what it is, and *Causa Cognoscendi*, the ground of knowledge, or that which explains how we know a certain event. For instance, I am riding in a tram-car in Calcutta, and see from some distance that a smashed up hackney-carriage and motor-car are obstructing the line. This is the *Causa Cognoscendi* to me that the tram-car will stop, but really the tram-car will stop by the application of the brake, which is the *causa essendi*. Cause corresponds to the *causa essendi*, and Ground or Reason to the *causa cognoscendi*. The former refers to change as real, the latter as knowable. The relation of Cause and Effect can thus be distinguished from that of Ground and Consequence, but the distinction does not imply any opposition. This distinction is, however, "more one of usage than of theory".[2]

In ordinary usage Cause is taken to imply time sequence. In this sense, it may be contrasted with Ground or Reason. Cause refers to *operation in time*, Reason does not.

9. **Quantitative Aspect of Causation.**—Science always aims at accuracy and precision. In physical and mathematical sciences and other departments of knowledge which allow of quantitative measurement, this aim is realised; but facts of our mental and moral life, which are always unique and qualitative, baffle all attempts of science to view them quantitatively. For that reason, we cannot, strictly speaking, have a *science* of Psychology or a *science* of Ethics. When we speak of them as sciences we only imply their methodical and genetic

[1] cf. Joyce, *op. cit.*, p. 119.

[2] Bosanquet, *op. cit.* I. p. 265.

treatment. Now, Causation admits of quantitative treatment only in physical sciences, and it is in their reference that the following remarks of Sir John Herschel[1] are applicable: "Numerical precision . . . is the very soul of science; and its attainment affords the only criterion, or at least the best, of the truth of theories, and the correctness of experiments . . . . Indeed, it is a character of all the higher laws of nature to assume the form of precise *quantitative* statement." Thus, where possible, science seeks after numerical accuracy.[2]

In its quantitative aspect, Causation is viewed as Conservation of Energy, an idea supposed to indicate a great advance in the scientific view of causality. The principle amounts to saying that energy has various forms, all mutually convertible, and that no energy is lost in such mutual conversion. Force that is extinguished in one form is created in another form. Clerk-Maxwell defines the *Principle of the Conservation of Energy* as follows:—

> "The total energy of any material system is a quantity which can neither be increased nor diminished by any action between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible."[3]

We can make this statement in reference to concrete material systems only, and no equation between the total possible energy of the Universe as a whole can be

[1] Herschel, *Discourse on Natural Philosophy*, §§ 115, 116.

[2] cf. "If we are to speak accurately we cannot say that eating stills hunger and drinking thirst, for a mouthful or a sip is no good; nor can we say that arsenic kills or quinine reduces fever, for it depends on the dose; it is inaccurate, again, to say that common salt is dissolved by water, for it is not true that any quantity of salt is dissolved by any quantity of water."—Sigwart, *Logic* (Eng. trans.), pp. 346, 347.

[3] J. Clerk-Maxwell, *Matter and Motion*, Ch. V., p. 60.

established on empirical grounds. As James Ward says, "Those who insist that the quantity of this energy in the universe must be constant seem to me in the same position as one who should maintain that the quantity of water in a vast lake must be constant merely because the surface was always level, though he could never reach its shores nor fathom its depth."[1] The principle simply means that energy is not lost in transformation from one form into another in a limited system. If we know the amount of energy lost, we can find it in some other form. If a kettle full of water being heated for half an hour is found empty, the water has simply assumed the form of steam through heat. Force is indestructible. The forms of Heat, Chemical Force, Electricity, etc., may interchange, but no amount of energy is destroyed thereby. Transference of energy is the final solution of change offered by science.

Now, Causation, viewed as Conservation, is the transferring of a definite amount of energy.[2] Bain explains it by means of the following examples :—

'When a ship is propelled by wind or by steam, the motion is said to be caused by those agents, which expend themselves in producing the effect. The expansiveness of steam is due to heat operating through the medium of water. The heat arises from the combustion or chemical union of coal and oxygen. The coal was the carbon of plants of former ages, whose growth demanded an expenditure of solar heat.'

The numerical equivalency between Cause and Effect can be measured in terms of a fixed unit. For instance, if an effect is measured to contain twelve units, and if the

[1] James Ward, *Naturalism and Agnosticism*, vol. ii. Lecture xiii, pp 76-77.

[2] cf. Bain, *Logic: Induction*, 1896, p. 30.

amount of work created by the known agents or causes is ten units, it follows on the principle of the Conservation of Energy that we have still to find out causes having the capacity of two units to make up the total twelve units of the effect. The capacity of the cause must be the same as that of the effect. This principle is particularly useful in testing the *adequacy* of our explanations.

But one difficulty cannot be overcome. The principle explains Causation as the transfer of Force or Energy; but causation is not so simple a process, it involves *Collocation* as well, which cannot be explained by this principle. By Collocation is meant co-existence of causal tendencies in certain relations or the circumstances which, though not the determining cause, are yet necessary for the production of the effect. It is defined by Bain as 'the completing arrangement' or 'the new arrangement of materials'. For instance, a mill is turned by the energy created by a waterfall. But unless the water is brought to bear on the mill and the sluices are regulated, the mill will not work. These two circumstances are, therefore, not energy but collocation, similarly, if a ceiling-fan is properly fixed and its machinery is quite in order, still it will not move and give the much-desired breeze unless the electric wire is also connected with it. Here the prime mover is the electric current, but the completing arrangement or collocation includes the connecting of the machinery with the electric wires and allowing the regulator to move from the zero point onwards. Thus it is said that the principle of Conservation explains Causation but has nothing to say as to how the completing arrangements (Collocation) are brought about.

10. **Causation Derived from Experience: Mill's Proof of the Law of Causation.**—We have seen that the Law of Causation is the Inductive Postulate or the Ground of

Induction. Now the question is, can this Law be proved on the basis of experience? The Rationalists say in reply that it cannot be so proved, that it is a necessity of our thought, a self-evident and intuitive truth. The other answer, given by the Empiricists, like Mill, is that the Inductive Postulate is decidedly *a generalisation from experience.*

Before criticising Mill's view we had better state it briefly in his own words. He states the principle thus—

"Every event, or the beginning of every phenomenon, must have some cause, some antecedent, on the existence of which it is invariably and unconditionally consequent." Mill argues—"If we suppose . . . the subject-matter of any generalisation to be so widely *diffused* that there is no time, no place, and no combination of circumstances, but must afford an example either of its truth or of its falsity, and if it be never found otherwise than true, its truth cannot be contingent on any collocations unless such as exist at all times and places, nor can it be frustrated by any counteracting agencies, unless by such as never actually occur. It is, therefore, an empirical law co-extensive with all human experience, at which point the distinction between empirical laws and laws of Nature vanishes."

Elsewhere he argues while speaking of Induction by Simple Enumeration: It is "delusive and insufficient exactly in proportion as the subject-matter of the observation is special and limited in extent. As the sphere widens, this unscientific method becomes less and less liable to mislead: and the most universal class of truths—the law of causation, for instance, and the principles of number and of geometry—are duly and satisfactorily proved by that method alone, nor are they susceptible of any other proof." [1]

[1] "*A System of Logic*," Book III. ch. xxi §3.

Thus, Mill attempts to prove the Law of Causation on the basis of Induction by Simple Enumeration.

11. **Criticism of Mill's Proof.**—But the method of Simple Enumeration cannot give us the categorical certainty that is implied in the Principle. The defects of this method have already been pointed out. Unlike Scientific Induction, it is unanalytic, and cannot, therefore, lead to the discovery of the regularity and interconnexion which underlies the variation and looseness of phenomena. It is powerless to determine the uniformity which transcends the apparently infinite variety of phenomena. It cannot explain the existence of negative instances and a horde of exceptions that are met with. Hence the Principle of Causation cannot be established by *inductio per enumerationem simplicem*.

But, it may be contended that possibly Mill had in mind the analytic method of Scientific Induction by which to prove the Causal Law. That would certainly be less open to objection, since the drawbacks of Simple Enumeration vanish in Scientific Induction. On its basis, the proof will be satisfactory. But there is one serious objection. If the Principle of Causation is *proved* by Induction, we have no right to set it up as the Standard or Ground of Induction. What is itself an induction cannot, at the same time, be the Criterion of Induction.[1] As the Standard of Induction, the Principle guides us in distinguishing between a genuine and a spurious induction, between legitimate and illegitimate inductive explanation. That being so, how could the Principle itself be derived from Induction? The inconsistency is obvious enough.

Again, Scientific Induction proceeds on the assumption that the exceptions we meet with are more apparent

[1] W. R. B. Gibson, *op. cit.* p. 456

than real, that there is more of law and inter-relation in phenomena than appears to us at first. But this very assumption, the Inductive Postulate, is, according to Mill, a generalisation from experience. Evidently, it is an example of the fallacy of *petitio principii.* While attempting to prove that the principle of causation is derived from experience, he is compelled to assume that it is found in the facts in order to make Induction possible. But Hume had clearly pointed out that the causal connexion could not be *found* in the facts of experience. The empiricists first read it *into* the facts before extracting it *from* them. Hence, the fallacy is obvious. On strictly experiential grounds the causal connexion turns out a mere 'fiction.' Experience furnishes us with no ground whatsoever to extract the principle of causation.

12. **Causation as a 'Necessity of Thought.'**—If causality cannot be derived from experience, it must be explained as an *a priori* principle, which exists in the mind as an intuitive or self-evident axiom, and accepted as an ultimate necessity of thought. It is that principle which makes our experience possible. According to Kant, it is a structural necessity of our mental constitution. According to Schopenhauer, causality is no less a pure perception than Space and Time; without Space, Time and Causality our experience is impossible. This, however, leads into the intricacies of Metaphysics, which we need not discuss here. We have shown how it is impossible to derive this notion from experience, which means that it is not *a posteriori.* If so, it must have existed *before* experience, in the sense of making our experience possible. Logic has to accept it as an *a priori axiom* without inquiring into its ultimate significance. This is the rationalistic explanation of the origin of Causality, and appears to us as sound.

But from the pragmatic standpoint, there is room for criticising this theory. Dr. Schiller, for instance, assails it on the following grounds[1]: –

(1.) The theory is no explanation of our procedure. Why assume an *ultimate* necessity of thought implying thereby a limit beyond which no further discovery was possible? Is this not dogmatism? It is quite possible that our 'ultimate fact' may turn out to be wrong. "Hence such things as 'intuitions,' 'necessities of thought,' 'ultimate facts of mental structure,' etc., should only be regarded as provisional halting-places of the scientific analyst and permanent structures of dogma should not be built on them." Now, we may say in reply that this criticism is perfectly true on the pragmatic basis of 'provisional and relative truths,' but we view them as partial aspects of Absolute Truth: hence, our standpoint being quite different, this criticism does not touch us. The pragmatist is one with us in holding that the causal principle is not derivable from experience: this leaves only one other alternative, *viz.*, to regard it as an *a priori* principle. It is more than a mere postulate: it is an axiomatic truth, derived from Reason and corroborated by Experience.

(2.) Dr. Schiller admits the ability of the *apriorist* theory to account for some points in our causal analysis that nonplussed the empiricist "If we are so constructed as always to import the idea of causation into our experience, it is a matter of course that we shall regard it as universal, and have the utmost confidence in it, until at least we learn from experience to distrust it". But, it is alleged, the rationalist theory fails to account for several facts, *e.g.*, the following:—

[1] cf. Schiller, *op. cit.* p. 290 ff.

(*i*) It fails to explain the distinction between *casual* and *causal* sequences. How to explain 'chance'?

Our answer is, that although we admit the distinction in popular language, there is no room for it philosophically. There is no such thing as 'chance'. What appears 'casual' to a limited view turns out 'causal' if viewed in the complete scheme of reality. If Aristotle enumerates 'chance' in his list of 'causes,' such inclusion is more from the ordinary than the strictly philosophical standpoint. We hold that the rigour of causality is such as not to allow anything to happen by 'chance.'

(*ii*) "What about the future? What is to guarantee on this theory either that our mental structure will remain unchanged so as to continue to import causality into its view of experience, or that the course of nature will continue to conform itself to the nature of our mind? Rationalism here seems as impotent as empiricism. It can never give us an indefeasible assurance so long as it dares not deny the possibility of change. And if it denied that, would its dogmas continue to be applicable to the world of our experience?" (*ibid*).

We reply that such scepticism cannot invalidate our theory. That we shall above all continue as 'human beings,' and that nature will continue to conform itself to our mind in order to make our knowledge possible is guaranteed by nothing else than Reason. Rationalism is *not* "as impotent as empiricism." Empirically, there is no *necessary connexion*, as Hume pointed cut, and we could not predict the future at all, neither could we speak of the

cause as *invariable*. But the idealistic standpoint is entirely different. We may, for instance, compare Hume's and Kant's standpoints thus—

Hume argued :	Kant argued :
Experience has no necessity.	Experience has no necessity.
The Causal Principle is derived from experience.	The Causal Principle has necessity.
∴ It has no necessity.	∴ It is not derived from experience.

It is Reason that guarantees the truth of our universal judgments and it is Reason that justifies our prediction of the future Rationalism does not deny *change*, but at the same time it does not view it as ultimate and absolute. In order to make change possible, there must be something changeless as its substrate. Rationalism, indeed, gives greater assurance than the wholesale scepticism of the Pragmatist.

(*iii*) "If it is true that human interference does nothing but vitiate 'fact', then the theory of Causation is certainly one of the most magnificently irrational parts of an incredible scheme of things". (*ibid*)

We do not deny that human personality does to some extent vitiate the process of analysis, but its effect is reduced to almost zero, if we extend the scope of observation, if the results are based on the observation of a large number of persons. We regard Humanism only as a factor within Absolutism.

13. **Causation as a Postulate : Pragmatic Standpoint.**—According to Pragmatism, there is still a third alternative, Causation is neither derived from Experience nor from the necessity of Reason but from Postulation. All axioms are really *postulates* at their root.[1] "Postulation," writes Dr. Schiller, "is a well-defined and typically

[1] On this view read Dr. Schiller's excellent contribution "Axioms as Postulates" in *Personal Idealism*, edited by Sturt, Oxford.

human way of obtaining general propositions which, when they have been sufficiently verified in use, may attain the highest degree of certainty and be looked upon as *axioms*. The principle of causation is one of the most valuable and characteristic of our postulates ".[1] He further claims that Postulation explains all the facts, which the other two theories failed to account for :—

(*i*). This view recognises the selectiveness of our thought.

(*ii*). As a postulate, the causal principle " combines the strength and avoids the weakness of its two competitors, and is far more plastic and adaptable than either."

(*iii*). It accounts for the distinction between *casual* and *causal* succession, and recognises the existence of the former. " A *casual* series of events is either one to which for some reason or other we refuse to apply the causal postulate, or one which we purpose to analyse into a number of distinct causal series ".

(*iv*). 'Chance' is easily explained Whatever does not interest anyone can be left without a 'cause', or if pressed further we may assign 'chance' as its cause.

(*v*). Postulates refer to the future and anticipate further confirmation. " It is obvious that we should gain nothing by assuming that in future the course of experience will be such as to defy causal analysis ".

(*vi*). One serious objection to the principle of Causation is that the causal succession can never be said to end, and that it lands us in a *regressus ad infinitum*. This objection

[1]*op. cit.*, p. 293.

vanishes only when we treat Causation as a Postulate. 'Cause' and 'Effect' are both selections made for human purposes and interests; hence we can stop anywhere—as soon as we arrive at a 'cause' that answers the purpose of our inquiry. In this way there is no infinite regress possible.

14. **Aristotle's Analysis of Causation.**—We have discussed the doctrine of Causation in its several aspects and have examined various definitions of 'cause'. One thing is evident: there is no agreement, even in sciences, as to the sense in which the term 'cause' is to be understood. A cause may mean any of the following:—

(*i*). An antecedent, *e.g.*, lightning may be said to be the cause of thunder; striking the hammer or pulling the trigger, the cause of gunshot.

(*ii*). A consequent, *e.g.*, I take exercise for the sake of my health: health is therefore the cause of taking exercise. Similarly prospective pleasure is the cause of my attendance at a theatre or a musical concert.

(*iii*). A law, *e.g.*, gravitation is the cause of the falling of bodies or of their weight.

(*iv*). A power, *e.g.*, a running stream may be utilised as the power to turn a mill. Similarly a waterfall may be utilised in generating electricity on a large scale.

(*v*). A person or agent, *e.g.*, a carpenter is the cause of the furniture that he makes; a sculptor is the cause of the statue that he carves out of stone.

(*vi*). An identity, *e.g.*, ornaments are made of gold and not of clay; earthen jars and pots are made of clay, not of gold.

Aristotle was aware of this confusion in the meaning of the word 'cause', which he viewed in general as something which positively contributed to the existence of something else; and in order to remove such ambiguity he made an attempt at a logical analysis of causation. He distinguished *four* kinds of causes; *viz.*, FORMAL, MATERIAL, EFFICIENT and FINAL. The first two are known as *intrinsic,* since they enter into the constitution of the thing itself, while the last two are termed *extrinsic*. The four causes may be illustrated in the typical example of a statue. The *formal* cause of the statue is the conditions which constitute it, *i.e.*, the form or type in the mind of the sculptor; the *material* cause is the matter of which it is made, *e.g.*, marble, bronze, etc.: the *efficient* cause is the sculptor himself, the power which changed the marble into a statue; and the *final* cause is the end for which the statue was made, *e.g.*, honour, profit, etc. The same applies to every material thing. Take this book on Logic: *formal* cause—the idea of the book in the mind of the author; *material* cause—paper; *efficient* cause—the auther himself: and *final* cause—literary fame or financial success.

Now, when the book is completed, the efficacy of the *efficient* and *final* causes is at an end. The book has *become* what it is, through these causes, but they are not necessary for its mere existence. The book may exist when the author is no more, and, also, after the end in view is realised. Hence, these two causes are called *extrinsic*. The other two causes, however, *viz.*, the formal and the material, may be called the causes of the *being* of a thing.[1] Without the operation of either of these causes, the effect would cease to exist. If the shape of the book is destroyed and it is reduced to pulp—*i.e.*, if the

[1] This distinction was recognised in Scholasic Logic as that between the *causa in fieri* (cause of becoming) and the *causa in esse* (cause of being).

formal cause ceases—the book will no longer be a book. And, if it were made of any *material* other than paper it would also no longer be a book. With this distinction in view, it is easy to understand the meaning of the Scholastic saying "CESSANTE CAUSA, CESSAT EFFECTUS": when the cause ceases, the effect ceases.

Mill criticised it in the following passage:—"Yet there were at all times many familiar instances of the continuance of effects long after their causes had ceased. . . . A ploughshare once made remains a ploughshare, without any continuance of heating and hammering, and even after the man who heated and hammered it, has been gathered to his fathers." This shows how Mill failed to understand the Aristotelian doctrine. Heating and hammering were necessary *before* the ploughshare was brought into shape, not *after* it has *become* a ploughshare. The man who heated and hammered it is also no longer required. But the material and the formal causes *are* necessary for the continuance of the effect. The ploughshare would cease to exist as such, if it were not made of iron or if it lost its specific shape.[1]

The Aristotelian distinction is also helpful in several other ways. For instance, when we speak of the reciprocity of the causal relation, we are not to mix up the *formal* and the *efficient* causes. It is the formal cause to which reciprocity applies: wherever

[1] Joyce also considers this example in bringing out the error in Mill's statement and says: A thing "*becomes* what it is through the final and the efficient causes. But as soon as we can say of it that it *is*, it depends on them no longer: their work is at an end. On the other hand, the material and formal causes are what make it to *be* a ploughshare Had it been made not of iron, but of some yielding substance, it would not be a ploughshare at all; and if it should be melted down and lose its shape, it would cease to be one." *op. cit.*, p. 247.

such cause exists, the effect must also exist, and *vice versa*. As Joseph observes:—"If with Aristotle we call the conditions which constitute anything the *formal* cause, and the event whose occurrence brings those conditions into being when they had previously not all of them existed, the *efficient* cause, we may say that the formal cause reciprocates or is commensurate with the phenomenon (as indeed anything must which can in any sense be called the definition of it: and the conditions into which it can be analysed may be called its definition); while the efficient cause seldom reciprocates."[1]

Aristotle's fourfold distinction is also useful in defining terms. Thus we have Causal Definitions—those that define by indicating either (*i*) the final cause, or (*ii*) the efficient cause. For instance, we define (*a*) a Pistol as a small weapon used for firing at a short distance; an Electric Fan as a mechanism with two or more blades used as a comfort in the hot weather; (*b*) Ague as an illness caused by the *Plasmodium malariæ* reaching the blood direct through the bites of mosquitoes, or indirectly through infected water or air. Essential Definitions are, on the other hand, formed by the *formal* cause,[2] by stating the genus and the differentia; and Genetic Definitions are constructed with reference to the material cause.

15. **Threefold Distinction of Causality in Hindu Logic.**—In Hindu Logic we have a threefold distinction of causality. Causality is a *relation* (सम्बन्ध), and may be viewed as Intimate or Coherent (समवायि), Proximate or Non-Coherent (असमवायि), and Instrumental (निमित्त). The first kind may be illustrated in

[1] Joseph, *op. cit.*, p. 451.
[2] cf. our *Elements of Deductive Logic*, p. 68; Joyce, *op. cit.*, pp. 156-158.

the case of 'threads and cloth': if there is no thread there is no cloth; 'thread' is the intimate cause of 'cloth'. Similarly clay is the intimate cause of jar, pot, etc., wood, of table, chairs, etc. Evidently it corresponds to Aristotle's "*material*" cause. The second kind, viz., Proximate or Non-Intimate cause, may be illustrated by saying that without the *conjunction* of the two halves of a jar, a jar cannot come into existence. Similarly threads might exist but they cannot produce cloth unless they are put together and arranged in the proper order. This cause is *proximate* to the Intimate cause, and is known as संयोग सम्बन्ध. We have nothing in Aristotle's classification exactly corresponding to this 'conjunctive' function of causality. But as the *conjunction* of the two halves of a jar, for instance, is a necessary step for giving the proper *form* to the effect (the jar), and as Proximate cause is 'intrinsic,' we might compare it with Aristotle's Formal Cause. It depends on the way in which we view the sense of *conjunction*. The third kind, *viz.*, Instrumental Cause, is illustrated in the weaver's loom or shuttle, without which cloth cannot be produced, although we may have threads and their 'conjunction'. In modern times handlooms have become curiosities, and cloth is prepared by machinery. In that case, the machinery itself would be the Instrumental cause. But even a machine cannot start itself, some agent is necessary for that purpose. Hence the agent may also be included under the Instrumental cause. Aristotle's Efficient Cause may, therefore, be placed under this category. But in Aristotle such causality rests in human skill or the agent himself, while in Hindu Logic the Instrumental Cause may refer to several other things besides, as we have illustrated above. In illustrating the Instrumental cause, we may also take the stock example of the 'jar.'

While clay is its material cause, the conjunction of its two halves (कपाल संयोग), its proximate cause; the stick (दण्ड) with which the potter moves his wheel, is said to be its *instrumental* cause. This kind includes all things *instrumental* in the production of an effect other than those covered by the Material and the Proximate causes. In that sense, Aristotle's Efficient and Final causes may all be included in the 'Instrumental' (निमित्त) cause of the Nyāya-Vaiśeshika school. Like Aristotle's 'Efficient' and 'Final,' the *Instrumental Cause* is extrinsic and does not enter into the constitution of the effect produced. Thus an effect may survive the destruction of its Instrumental cause. For instance, after weaving a piece of cloth, the loom may be thrown into fire, or the weaver himself might die—still the cloth as such will continue to exist. On the other hand the effect necessarily ceases with the destruction of either of its 'Material' and 'Proximate' causes.

Towards the end of Kanāda's *Vaiśeshika-Darśana*, we have a further exposition of the three kinds of cause. The question is taken up: how do we know that a substance is an Intimate (Coherent) cause? The answer is that such knowledge is derived from the co-inhesion of the effect, *i.e.*, substance is *intimately* related to effects, viz., compound substances (द्रव्य), qualities (गुण), and actions (कर्म).[1] Thus the Intimate Cause must always refer to a *substance*; it can therefore be called the 'Material' cause.

As regards the second kind, *viz.*, the Non-Coherent or Proximate Cause, Kanāda explains that such causality resides in *action* (कर्म), that actions are Non-coherent causes.[2] It is through co-herence in the co-herent

[1] *cf.* Kanāda's sutra : "कारणमिति द्रव्ये कार्यसमवायात्" (X. 2. 1).

[2] cf. "कारणे समवायात् कर्माणि" (X. 2. 3). Here the word कर्माणि means असमवायिकारणानि.

cause that such causality is recognised.[1] It is therefore 'Proximate' with reference to the Co-herent cause. Then, again, Non-Coherent causality resides in *quality* (गुण) as well, since qualities coinhere in the same substance.[2] The last kind, *viz.*, the Instrumental or Efficient Cause, is illustrated by him in the production of colour, etc., by baking on fire. The differentiating character of fire, *i.e.*, heat—which is a special attribute of fire—is (through co-inherence with the conjunct) the Efficient cause of colour, etc., produced by baking.[3] The general definition of this (निमित्त कारण) kind of cause is a cause other than the Co-inherent (Material) and Non-Co-inherent causes.

15. **Principal Theories of Causation in Hindu Logic.**—We have already discussed the views of Causation as sequence and coexistence respectively. It may be of some interest to see how this problem was treated in Hindu Logic. The Nyāya-Vaiśeshika systems of Gōtama and Kanāda adopt the empirical standpoint, while the Sānkhya and the Vedānta of Kapila and Vyāsa elaborate the idealistic point of view.[4] Thus there are two principal theories; the one maintained by Gōtama and Kanāda is known as 'the doctrine of the non-reality of effect' (Asatkāryavāda असत्कार्यवाद), that of Kapila and Vyāsa as 'the doctrine of the reality of effect' (Satkāryavāda

[1] cf. "कारण समवायस्य संयोगः पटस्य" (X. 2. 5), *i.e.*, Conjunction through Co-inherence in the Co-inherent cause is the Non-Coherent cause of an effect, such as a piece of cloth.

[2] cf. "तथा रूपे कारणैकार्थसमवायाच्च" (X. 2. 4).

[3] cf. "संयुक्त समवायादग्नेर्वैशेषिकम्" (X. 2. 7).

[4] Each of the Hindu Systems of Philosophy contains Logic, along with Epistemology, Metaphysics, Psychology, etc. cf. our *Elements of Deductive Logic*, Appendix II. p

सत्कार्यवाद). The following is a very brief statement of these views :—

Kanāda and Gōtama's Empirical Theory of Causation :—

Thesis : Cause and Effect stand in the relation of sequence and can never be identical [1]

Proofs :—

(1.) Cause and Effect appear in our consciousness as separate (विलक्षणबुद्धित्वात्). We never identify a piece of cloth with the threads of which it is made. When so made we do not look upon it as 'threads arranged in a certain order' but as 'cloth.' So too, a jar is not identical with its cause clay.

(2) They are denoted by different words (शब्दभेदात्). No one speaks of 'threads' as 'cloth', **and** *vice versa.*

(3) Their functions are different (कार्यभेदात्). Only a jar and not a lump of clay can be used for carrying water ; and a wall can be built of clay and not of jars.

(4) They are characterised by sequence in time (कालभेदात्). Cause is always the antecedent(पूर्ववर्ति)and Effect the consequent (परवर्ति). This is taught by our everyday experience.

(5) They are distinguished as to their form (आकारभेदात्). Clay exists in clods and lumps, but its effect, the jar, is round and hollow. Besides, the jar may be destroyed, while the clay continues to exist.

(6) Also as to their number (संख्याभेदात्). *Many* threads produce *one* piece of cloth.

[1] न कारणात्कार्यस्यानन्यत्वं संभवतीति काणादाः

(7) If cause and effect were identical, the efficiency of the Agent in bringing about an effect would be useless. Without the instrumentality of the potter, clay will never mould itself into the form of a jar.

The fundamental point of controversy is discussed as follows—

Asat-kārya-vāda: The effect (कार्य) is non-existent (असत्) before its creation. The activity of an agent creates a kind of new effect from the cause, in which it did not exist before the operation of the agent. For instance, a jar, although made of clay, is non existent *quá* jar before the potter moulds the clay into this form. The potter creates a new effect (घट) from the clay (मृत्तिका). Hence, prior to its production, the effect as such is *non-existent*.[1] This view is rejected by the idealistic school :—

Sat-kārya-vāda: The effect (कार्य) does exist (सत्) even before its manifestation as such. Cause and Effect are identical.

[1] This is the doctrine of the Nyāya-Vais'éshika. cf. Kanāda's sūtra (IX.I.I). क्रियागुण व्यपदेशाभावात्प्रागसत् which means "An effect is non existent before its production, since actions and qualities are not asserted of it." If the effect were existent during that time, actions and qualities would be predicated of it, as they are in the case of an effect *after* its production. But there is antecedently no such assertion of qualities and actions, as is after the production, *e.g.* of the jar, such as 'the jar is at rest', 'the jar is in motion', 'it is of a black colour', etc. Hence the Idealistic Doctrine of the pre-existence of an effect in its cause must be rejected. Thus घटोत्पत्तेः पूर्वं घटप्रागभावस्तिष्ठतीति स च प्रतियोगिजनकः कथमन्यथा कारणान्तारसत्वे उत्पन्नस्य न पुनरुत्पादः

. Non-existence can never be transferred into existence. If the effect were absolutely non-existent before its production, it could by no means be brought about. We can, for example, extract oil from mustard-seeds, but never from sand. Every effect exists potentially in its material cause, and is only *manifested* as such through the activity of the agent. The jar in question exists in clay even prior to its being moulded as such; the potter's activity is only a suitable occasion for its manifestation as a jar. Being and Non-being are not mutually reciprocating: one cannot be transformed into the other.[1]

The Empirical school would again reply :—*Asat-kārya-vāda*: The abova argument is unsound. If the effect exists in the cause prior to its production as such, the agent's activity would become quite purposeless. If it is said in reply that such activity is directed towards the *manifestation* (अभिव्यक्ति) of the effect which is latent in the cause, it means that in addition to the effect "jar", another effect, *viz.*, "manifestation" has also come into being through the agent's activity—in case it is denied, it is impossible to perceive the manifestation of the jar. Well, then, this will lead us to an infinite regress, since we can demand "manifestation" of "manifestation", and again a "manifestation" of that, and so on. If on the other hand the "manifestation" of "manifestation", is denied, then doubtless

इहेविदानीं घटो भविष्यतीत्यादि प्रत्यक्षमपि प्रागभावे मानमस्ति In this way the antecedent non-existence (प्रागभाव) of घट is proved. This sums up very briefly the Nyāya-Vaiséshika standpoint of Causality.

[1] Neither non-existence is brought into being nor is existence ever made non-existence : "नासदुत्पद्यते, न च सत् विनश्यति" also cf. नासतो विद्यते भावो नाभावो विद्यते सतः" (Gita)

there is no infinite regress but then we should *always* perceive the jar *quá* effect; but that we do not—hence the effect does not co-exist with the cause.

This is again answered by the Idealistic school as follows:—

Sat-kārya-vāda.– But there is no special law regulating the "manifestation" of the jar through the agent's activity. For instance, a lamp, which is admittedly the agency by which the forms of various objects are manifested in a dark room, observes no special rule in its operation—anything that is near it is manifested—similarly the potter's activity is not necessarily connected simply with the manifestation of the jar: while the activity is present, the form of the jar is itself manifested out of the clay. Hence, the effect is identical with the cause.[1]

We shall not follow this Discussion further, as it is more of the metaphysics of Causality.

16. **Principle of the Uniformity of Nature.**—It is usually maintained that besides Causation there is another principle, called the Uniformity of Nature, which is also a necessary assumption of Induction. Before discussing the relation between the two principles, we shall first explain the meaning of the 'Uniformity of Nature, which is also called the Uniformity of Causation.

The Principle may be variously enunciated as follows:—

(*i*) The *same* cause will always produce the *same* effect.[2]

[1] 'कारणव्यतिरिक्तं कार्यं नास्तीति कारणादनन्यत्कार्यम्" (श्रीभाष्य)

[2] **Its converse is the Reciprocity of Cause and Effect:**
'Every effect has always the *same* cause' (*i.e.*, reciprocates with the cause).

(*ii*) Nature repeats itself : it is always uniform.

(*iii*) The future will resemble the past.

(*iv*) Nature is governed by Laws.

Now, is it true to say that Nature is uniform? In a sense, Nature is never uniform. It is a continuous flux, an uninterrupted flow of happenings, whose movement cannot be arrested at any point even in thought except by picturing a false view of it. The cinematographic representation of the process of change is entirely false and misleading. No two movements are ever alike, no two men are absolutely similar, no two leaves or pebbles are an exact prototype of each other, the past never repeats itself, and you cannot jump in the same river twice. That is perfectly true so far as it goes, but *mere change* cannot explain the phenomena of nature; it cannot exist except on the basis of *identity*. If *change* were the ultimate fact, and no *identity* existed, nature would be entirely without any system or law, and at every step we should be confronted with novelty. For want of identity all recognition would be impossible; a brother will not be able to recognise his brother, the father his son; water which is cold now may burn my finger at the next moment; and all knowledge would become impossible. The fact is that change and identity are relative terms. With mere change the universe would be a place of mere surprise and novelty, and with bare identity it would be a block universe, lifeless and petrified as it were. There is identity in change—or *systematic identity*. The general conditions in which change realises itself do not change themselves; if they did, the very notion of change would vanish. The past does not repeat itself in the absolute sense; since an absolute recurrence of facts is impossible. From the standpoint of Absolute Idealism the distinction between past and

future does not hold; they belong to one *system*. What the Principle of Uniformity maintains is that so far as things are qualitatively the same they have the same attributes, and so far as conditions precisely the same in kind occur, they must, if there is such a relation as cause and effect at all, have the same effect.' As Joseph aptly remarks :—"To suppose that the same cause—other things being equal—can have different effects on two occasions is as much as to suppose that two things can be the same, and yet, so far their attributes different".[1]

Without the assumption of Uniformity, the organisation of all our knowledge and experience would be impossible, and the universe would be unintelligible and irrational. Mach makes the following observations on this point :

"In the infinite variety of nature many ordinary events occur; while others appear uncommon, perplexing, astonishing, or even contradictory to the ordinary run of things. As long as this is the case we do not possess a well-settled and unitary conception of nature. Thence is imposed the task of everywhere seeking out in the natural phenomena those elements that are the same, and

[1] *op. cit.* p. 378 :—"To say that the same thing acting on the same thing under the same conditions may yet produce a different effect, is to say that a thing need not be what it is. But this is in flat conflict with the Law of Identity. A thing, to be at all, must be something, and can only be what it is . . It may be replied that no two things ever are the same, and that no one thing ever is the same for two successive moments. The fact of change is not disputed, nor the difficulty of finding two things that are qualitatively the same. But if the effect of the second is different, that must be because of its qualitative difference from the first, and not merely because it is a second: and so far as it is qualitatively the same, the effect must be the same also: It being understood of course that to sameness of effect qualitative sameness is equally necessary in all the material conditions. To deny this is to deny the possibility of reasoning altogether." (*ibid.*)

that amid all multiplicity are ever present. By this means, on the one hand, the most economical and briefest description and communication are rendered possible: and on the other, when once a person has acquired the skill of recognising these permanent elements throughout the greatest range and variety of phenomena, of seeing them in the same, this ability leads to a *comprehensive, compact, consistent*, and *facile conception of facts*. When once we have reached the point where we are everywhere able to detect the *same* few simple elements, combining in the ordinary manner, then they appear to us as things that are familiar, we are no longer surprised, there is nothing new or strange to us in the phenomena, we feel at home with them, they no longer perplex us, they are explained."[1]

17. **Mill on the Uniformity of Nature.**—Mill holds that the Principle of the Uniformity of Nature is implied in all inductive inference. He writes:—"We must first observe that there is a principle implied in the very statement of what Induction is ... namely, that what happens once will, under a sufficient degree of similarity of circumstances, happen again" (Bk. III. Ch. 3 §1). He further tells us:—"Every induction may be thrown into the form of a syllogism, by supplying a major premiss. If this be actually done, the principle which we are now considering, that of the uniformity of the cause

[1] Mach, *Science of Mechanics*, Eng. trans., pp. 5-6, quoted by Welton, *op. cit* ii., p. 9.

On the various interpretations of Uniformity of Nature see also Bosanquet, *Logic*, I. Ch. VII. There the purely mechanical, the quasi-teleological and the really teleological views are distinguished. T. H. Green, Dr. Bosanquet and several others speak of the *Unity of Nature* instead of the *Uniformity*. They hold that *unity* implies *uniformity*. The view is quite consistent with Absolute Idealism.

of nature, will appear as the ultimate major premiss of all inductions." (*ibid.*)[1]

According to Mill the Uniformity of Nature consists of several uniformities. These he divides under two heads: (1) of Coexistence, and (2) of Succession. Of the first he instances the laws of number and space; and all uniformities which do not come under the second head. Natural phenomena coexist in space. The law that all fluids have buoyancy is an induction of coexistence; so also the law that all metals are good conductors of electricity. This means in general that the attributes of a thing coinhere in it, or coexist with it. Water has certain properties; wherever there is water, the properties will also be there—this is a uniformity of co-existence. Then again, in Geometry, for instance, we have the truth that any two sides of a triangle are together greater than the third. Thus wherever a triangle is formed, the law will hold good.

On the other hand, the Uniformities of Succession are those in which a certain phenomenon is universally followed by another phenomenon. To these is given the name of *Causation*.[2] According to Mill, therefore,

[1] Whately also declared that every induction was a syllogism with the major premiss suppressed; and, when supplied, the major premiss lays down: 'what holds true of this, that, and so on, holds true of all similar cases.' cf. "The universe, so far as known to us, is so constituted that whatever is true in any one case, is true in all cases of a certain description; the only difficulty is to find what description" [Mill, *op. cit.* III. 3].

[2] According to Bain, the Uniformity of Nature may be distributed under three heads, (1) Coexistence (as Coinherence of Attributes), (2) Succession (Causation), and (3) Equality. Induction has to deal with these three cases only, and we are further told that in the actual working of Induction, we find it to be almost entirely absorbed with Causation, *Vide* Bain, *Logic*; Induction, ch II.

Causation is only *one* kind of uniformity, and is not synonymous with the Uniformity of Nature.

Mill derives the Principle of the Uniformity of Nature from experience. He says, the Principle " is itself an instance of induction, and by no means one of the earliest which any of us, or which mankind in general, can have made. We arrive at this universal law by generalisation from many laws of inferior generality. . . As, however, all vigorous processes of induction presuppose the general uniformity, our knowledge of the particular uniformities from which it was first inferred was not, of course, derived from vigorous induction, but from the loose and uncertain mode of induction *per enumerationem simplicem.*" [1]

This means that first we discover 'particular uniformities' as *enumerative* inductions, which are, for that very reason, bound to be more or less hazardous generalisation, not of much value for science. And then we ascend from them to the 'general uniformity.' Thus, Mill teaches that our belief in the Uniformity of Nature is ultimately derived from observation of facts.

But the inconsistencies and difficulties of this position are obvious. We have already treated them in connexion with Causation. The same objections practically apply to Mill's derivation of Uniformity from observation. Mill's attempt breaks down. The Principle cannot be derived in this manner, and if it were an induction itself, how could it be taken as the *ground* of induction. Sigwart says :—" If we had needed merely to open our eyes in order to see 'uniformity in the course of Nature' everywhere before us, belief in the thorough going constancy of the way in which causes act would not have been so slow to arise nor have been still only a scientific

[1] *op. cit.*, Bk. III. ch. 21 §2

and not a popular belief. nor would the tendency to make capricious powers, demons and gods, responsible for what happens in the universe have been so deeply rooted."[1]

From the Pragmatic Standpoint it is claimed that the true meaning of the Principle makes it quite unnecessary to assume the task of explaining how it could be derived from experience. The Principle should not be taken for more than the statement of the *inductive problem*, 'how to find a correct general description for all cases to which a given particular inference should be extended?' Further, as Sidgwick says, the Principle can hardly be treated as an *axiom*, since "it is indisputable only because it carefully avoids making any assertion which can be tested in experience."[2]

18. **Relation of Causation to Uniformity of Nature.**—Logicians, as a rule, declare these two Laws to be two different things. We have already seen how Mill, Bain and others look upon Causation as a species of Uniformity; *i.e.*, all causation is uniformity but not all uniformity causation—only that of *succession* is so. It is usually said that the Principle of Causation is by itself insufficient as the Ground of Production, and rests on that

[1] Sigwart, *Logic* (Eng. Trans. ii. p. ııı.)

[2] A. Sidgwick, *op cit.* p. 122, also cf. "The Uniformity of Causation, though it enunciates a sound methodological rule, is by no means the absolute and intractable principle that has been supposed. Instead of guaranteeing the uniformity of events, it is the latter which gives it a meaning and a status in the world of reality."—Schiller, *op. cit.*, p. 303.

"The whole value of the Principle of Uniformity consists in its furnishing a formula for the extension of our other beliefs beyond our actual experience. Transcendentalists, indeed, call it a form of Reason, just because it is presupposed in all knowledge; and they and the Empiricists agree that to adduce material evidence for it, in its full extent, is impossible"—Carveth Read, *op. cit.*, p. 264.

of the Uniformity of Nature. That is to say, we may grant that 'every event has a cause' (Causation), but it does not follow from it that 'the same cause must always produce the same effect' (Uniformity of Nature), and that 'the effect reciprocates with the cause' (Reciprocity).

We, however, hold that the fundamental axiom of Induction is the Principle of Causation, which covers that of Uniformity of Nature as its corollary, and that the two principles cannot be treated independently of each other. Instead of 'Causation' resting on 'Uniformity,' it is the latter which depends on the former. To prove our contention we have to point out the serious inconsistencies that follow from the position that 'the same cause need not always produce the same effect, neither may the same effect be always produced by the same cause.' In other words, we have to examine the position that a cause may not act uniformly.[1]

We maintain that the very notion of cause necessarily involves the idea of uniformity: that a cause must necessarily act uniformly. To deny this is to deny causation itself. The causal connexion is a necessary connexion, and therefore a universal connexion also. If A and B are causally related, it follows that A *must* produce B, and B must be produced by A. If they were not necessarily connected, the words '*must*' and '*produce*' would be emptied of all meaning. Anything would produce anything, the universe would be without any reign of law or order. If causation did not involve uniformity, no universal laws could be arrived at and generalisation would be impossible. There would be no reason to connect a change with any one rather than the other thing. The truth is that if A is the cause of

[1] This point has been admirably worked out by Joseph *op. cit.* p. 380 ff. We agree with him in taking Causation to imply Uniformity necessarily.

B now, it must be so always. For, as Joseph puts it, "if it can be the cause now, and not another time, how am I even to tell whether it is the cause now or not." [1]

If a cause did not act uniformly, that is to say, if the same cause under the same conditions could produce a different effect, it would amount to saying that nothing possesses any determinate nature, which would contradict the Law of Identity. As Joseph observes: "A thing, to be at all, must be something, and can only be what it is. To assert a causal connexion between *a* and *x* implies that *a* acts as it does because it is what it is; because, in fact, it is *a*. So long therefore as it is *a*, it must act thus; and to assert that it may act otherwise on a subsequent occasion is to assert that it is something else than the *a* which it is declared to be". (*ibid*). Again—"So far then from the causal character of a sequence being derived from its uniformity, its uniformity is derived from its causal character. We avail ourselves of the uniformity which must characterise causal sequences so far as they are repeated, to determine which of the sequences that we observe are causal; and that is why the repetition of an event under diversity of conditions is of such assistance to us in determining what conditions are essential, or material, to its occurrence." (p. 377).

The Law of Causation is otherwise called the Law of

[1] *op. cit* p 375. Joseph thus sums up his position. "There is no need then to distinguish the Law of Causation from the Uniformity of Nature; for a cause which does not act uniformly is no cause at all; and if we are looking for the presuppositions of inductive inference, it is plain that the only connexions whose existence would justify such inference are uniform connexions. But two cautions must be given here. First, it must not be imagined that uniformity is the *fundamental* element in the conception of causal connexion, but *necessity* or *law*. Secondly, we must be careful not to confuse a conditional with an unconditional necessity." (p. 376).

Universal Causation, which correctly conveys the idea that causation must be universal, and it can possess that character only if it operates *uniformly*. It seems to us a contradiction in terms to speak of a cause not acting uniformly: in that case, it could by no means be called *cause* at all. We therefore conclude that the Principle of Causation and the Uniformity of Nature are not to be treated as two different things: they are identical; the only distinction is that the latter constitutes an aspect necessarily covered by the Law of Causation. The ultimate Presupposition of Induction is, therefore, nothing more than the Law of Causation. It is the foundation on which all inductive inference rests. It cannot be derived from experience but is a form of our reason, presupposed in all knowledge and without which the universe would be unintelligible.

SUMMARY

Induction is based on *generalisation*. We have now to enquire, by what right we ever generalise from experience.

The plain answer is that induction *assumes* the existence of necessary and universal connexions in nature and is called upon to determine the elements between which such connexions exist.

This assumption is expressed in the Law of Causation: "Every event has a cause." This Law is only a special application of the Law of Sufficient Reason, and covers the Law of Uniformity of Nature ("The same cause must always have the same effect") and its converse, the

Reciprocity of Cause and Effect ("Every effect always has the same cause").

Two principal views of Causation :—

I. Empirical (cf. Mill, Bain.)

Qualitatively : Cause is the invariable and unconditional antecedent of an event.

Quantitatively : Cause is equal to the Effect. The essence of Causation lies in the transformation of energy.

∴ Causation = Sequence in time.

Cause : Effect :: Antecedent : Consequent.

II. Rationalistic (cf. Sigwart, Green, Bradley, Bosanquet) Cause is complete ground, hence identical with effect in a system of reality.

Causation = Coexistence.

In *popular* phraseology, Cause = anything in the absence of which a phenomenon would not come to pass: but *scientifically*, Cause = the sum-total of positive and negative conditions.

In the former sense, many different causes may, on different occasions, produce the same effect. That is to say, the doctrine of the Plurality of Causes, is consistent with the popular view of Causation. But in the scientific or philosophical sense, there is no room for it. The same event will always be brought about by the same cause. There are many causes of death only because there are many kinds of death. Mill's doctrine of the Plurality of Causes has, therefore only an *apparent* validity, and breaks down on scientific analysis. The relation between Cause (as complete ground) and Effect is *ideally* reciprocal or reversible.

The Plurality of causes must be distinguished from the Composition of Causes. The former maintains that the same effect may at different times be produced

by different *total* causes. The latter means that a number of conditions or partial causes may together contribute to produce a certain effect.

Mill's Doctrine of Causation—

(1) *Statement*: Cause = the sum-total of conditions, positive and negative taken together.

Cause = the invariable and unconditional antecedent. Causation = Succession in time.

(2) *Criticism*:

(i) Purely on the basis of experience, the future can never be predicted. Mill can speak of *unvaried* but not *invariable* antecedent.

(ii) For the same reason, he has no right to speak of any *unconditional* antecedent, since that would mean an unwarranted leap from the mere sequence of phenomena in time.

(iii) Mill's phrase "the sum-total of conditions" is rather unfortunate:—

(*a*) Because it may indicate a wrong method of combining the factors. A better expression would be "the sum of the conditions".

(*b*) Because it is not clear whether it is limited to *relevant* conditions or not.

1 If it is, it stands in flat conflict with Mill's doctrine of the Plurality of Causes, which breaks down if cause refers to *relevant* conditions alone.

2 If it is not so limited, it brings in a confusion between 'cause' and 'condition.' No analysis will then be possible, and Causation will be a tautology.

(iv) Mill is anxious to discard 'efficient causes' but he is forced to admit them while speaking of the *unconditionality* of the causal connexion.

(*v*) Causation is not mere succession in time. It is a continuous process, whose moments are not separated *by time* but *in time*, and such separation is marked by an *ideal* line only. Mill's conception of Cause is imperfect. He is only aware of discreteness but is blind to continuity. Causation is not *in* succession, though it remains *through* succession. It is the ideal reconstruction of a continuous process of change.

Cause as complete ground is identical with Reason. They can only be distinguished in their imperfect stage: Cause as a species included in a common genus with the incomplete forms of Ground. They are also distinguished as *causa essendi* and *causa cognoscendi* respectively.

Mill derives the Law of Causation from experience (by Induction *per enumerationem simplicem*). But this is open to serious objections:

1. Induction by Simple Enumeration fails to give us categorical certainty, and this is not the method used in arriving at scientific generaliations.
2. As an empiricist Mill cannot derive universal principles from experience, since experience can never yield them.
3. If the Causal Principle is a generalisation from experience, *i. e.*, if it is derived by induction, how could it be taken as the Ground of Induction? Thus Mill commits the fallacy of *Petitio Principii*.

Causation is, on the other hand, a 'necessity of thought, a form of Reason, without which Nature and our experience become quite unintelligible. It is not derived from experience, but its validity is shown by its applica-

tion to experience. It is an *a priori* principle, self-evident to our reason.

From the Pragmatic standpoint, Causation is merely a Postulate, and not a self-evident axiom. It is claimed that this view accounts for the distinction between *casual* and *causal* succession, and combines the strength and avoids the weakness of the two rival theories.

Aristotle distinguished *four* causes of every material thing : *e. g.*, the causes of a statue are :—

Intrinsic
- formal cause—the form in the mind of the sculptor.
- material cause—the matter of which it is made, *e. g.*, marble.

Extrinsic
- efficient cause—the sculptor himself.
- final cause—the end or which the statue was made.

In Hindu Logic *three* kinds of causes are distinguished :—

Intrinsic.
1. 'Intimate,' 'Coinherent,' (समवायि), *e.g.*, 'clay-jar', 'thread-cloth,' etc. Corresponds to Aristotle's "Material" cause.
2. 'Non-intimate,' 'Non-coinherent,' 'Proximate' (असमवायि), *e.g.*, conjunction of the two halves of a jar produces a jar, conjunction of threads produces a piece of cloth. No corresponding notion in Aristotle.

Extrinsic
3. 'Instrumental,' 'Operative' (निमित्त) *e.g.*, 'stick-jar,' 'shuttle-Cloth,' etc. Corresponds to, but includes much besides, 'Aristotle's "Efficient" cause.'

The Law of the Uniformity of Nature, which says that 'the same cause will, under like conditions, always produce the same effect' is not to be treated as an

additional and separate ground of Induction. It is covered by the Law of Causation. The causal relation is *universal* and *necessary*. If the cause did not operate uniformly it would cease to be 'cause'.

The ultimate Ground of Induction is, therefore, the Principle of Causation.

Questions and Exercises

1. What are the Presuppositions of Induction?

2. How is the Law of Causation related to that of Sufficient Reason?

3. What variety of meaning has been assigned to the word Cause?

4. Distinguish between the popular and the scientific notion of Cause. Can you account for the divergence between the two views?

5. "Every phenomenon has a cause". Discuss the meaning and origin of this principle.

6. In what sense is the word Cause used in

(i) "Every cause has an effect,"

(ii) "The cause is equal to its effect,"

(iii) "The cause is the effect."

7. Critically discuss Mill's theory of Causation, and compare it with any other you know of.

8. Discuss the proposition that the cause invariably precedes the effect.

9. What is the attitude of recent discussions on logical doctrines towards Mill's theory of causation?

10. Bring out the implications of Cause as the sum-total of positive and negative conditions taken together.

11. "A cause is an effect concealed; an effect is a cause revealed". Examine this statement critically.

12. Discuss the relative merits and significance of Causation as (*a*) sequence, and (*b*) co-existence.

13. What is meant by saying that cause and effect are only "two aspects of one phenomenon"? What is the bearing of this view on the doctrine of the Plurality of Causes?

14. State Mill's doctrine of the Plurality of Causes. Distinguish between 'Composition' and 'Plurality' of Causes.

15. Comment on the following statement:—"As often as the same circumstances are repeated, the same effect will follow, yet when the effect is the same we cannot infer that the cause is the same too."

16. Distinguish between—(a) Cause and Condition. (b) Cause and Reason (Ground). (c) *causa essendi* and *causa cognos Cendi*.

17. Distinguish the *qualitative* and *quantitative* aspects of Causation. Bring out the meaning of Causation as Conservation of Energy.

18. "*Cessante causa, cessat effectus*" Explain.

19. Comment on the following views:—

(*a*) "Here all things always seem the same."

(*b*) Nature is a constant flow. No two things are ever alike.

20. Distinguish between the uniformities of succession and those of co-existence.

21. Critically examine Mill's Proof of the Law of Causation from (1) the rationalistic, and (2) the pragmatic standpoints.

22. In what relation does the Principle of the Uniformity of Nature stand to the Causal Principle?

23. Compare the following ways of expressing our belief in the Uniformity of Nature :—

(*a*) The future will resemble the past.

(*b*) Nature will repeat itself.

(*c*) The unknown will resemble the known.

(*d*) The Universe is governed by Laws.

(*e*) The absent is like the present.

24. Discuss Mill's view that the principle of the Uniformity of Nature is arrived at by Induction.

25. Explain.—

(*a*) "It is part of the conception of Cause to act uniformly ; and so far, the Universality of Causation and the Uniformity of Nature are the same thing".

(*b*) "A cause which does not act uniformly is no cause at all".

26. "The Uniformity of Nature is the ultimate Major Premiss in all Induction." (Mill). Discuss.

27. Discuss the statement : "A vigorously exact interpretation of causal connexion would render the law of causation scientifically useless."

CHAPTER V

OBSERVATION AND EXPERIMENT

1. **Analysis of the Given.**—Before we consider certain well-recognised methods of establishing causal connexion between phenomena, it seems necessary to speak of two of the several operations without which inductive reasoning cannot proceed—Observation and Experiment.

Induction guides us in the discovery of laws from a close examination of facts. But at a first glance nature does not present us anything like ordered and systematically arranged phenomena; we have only a chaotic mass of facts. There is no possibility of escaping such chaos except by an effort of the mind to put order and system after a close scrutiny. Our faith in teleology, our deep-rooted conviction in the regularity and rational order of Nature compels us to regard chaos as only apparent and we are called upon to analyse the given facts with a view to discover law and order. Facts or phenomena cannot yield their own explanation; it is the mind which can interpret them. Before it is possible to discover laws, the Given is to be carefully analysed. The object of such analysis is, in the first place, to distinguish between relevant and irrelevant facts in any scientific investigation, and secondly, to find out the invariable and necessary circumstances under which the phenomenon under study occurs.

The sifting of the relevant from the vast mass of facts

presented to us for examination implies *selection.* We have to isolate those elements which are relevant to the inquiry in hand and confine our attention to them. Without this no progress in knowledge is possible. Even this simplest act of perception involves selection. Well, then, in our analysis of the Given we first of all bring together out of the totality of presentation only those facts that are relevant to our purpose so that we may later on confine our attention to their interpretation alone. This defines for us the facts we have to study and is the first fundamental step towards the discovery of causal connexions.

The next step we take is the elimination of those circumstances under which a certain phenomenon necessarily occurs. To determine that we should also have to find out the circumstances under which we might have expected the phenomenon to occur, yet it does not occur. This negative operation will make us doubly sure as to the circumstances which are absolutely necessary for the production of a phenomenon. Elimination is one of the most important operations in Induction and we shall have occasion to speak of it further under the Experimental Methods. Suffice it to say here that we must be very careful in this part of our analysis: we must not omit any circumstances under which a fact appears, otherwise our further inquiry as to which of them is causally connected with the phenomenon studied may be vitiated.

The first steps in the analysis of the Given, are taken by the operations known as Observation and Experiment[1]—which are usually described as two different modes of interpreting Experience.

[1] "Observation and Experiment are the *material* grounds of Induction" (the *formal* ground being the Principle of Causation)—Carveth Read, *op. cit.*, p. 191.

2. **Observation.**—Observation is one of the processes by which we obtain knowledge of natural phenomena. It requires an exercise of our senses, inasmuch as we have to note the facts as they occur. We cannot, however, note the countless facts presented to us by nature every moment; what we observe is determined by our own interest and purpose. Hence, Observation is always *selective*. The same work of art will appeal differently to an artist and a layman. The former will discover in it much more than the latter. A student of physics will study a rainbow differently from the boy flying the kite. He will be interested in the formation and amalgamation of the seven colours, etc., while the other boy will notice the phenomenon in passing and feel no interest in the arrangement of the colours, red, orange, green, blue, yellow and violet. Similarly, the phenomena of wind, rain, dew, lightning, etc., will be observed differently by different people. He who is equipped with more knowledge will be able to discover more in the same phenomenon, and what precisely he will note will be determined by his *interest*.

Observation is also made, as a rule, in the light of some hypothesis. We first select a certain phenomenon, mark it off from its antecedents and consequents, frame a hypothesis as to the antecedent with which it is causally connected, and verify the hypothesis by means of further observation. Man cannot gaze at a thing or a phenomenon with a vacant mind: he must needs exercise his intelligence. Although he sees with his eyes, hears by his ears, he interprets his sensations all the time. The senses are only the instruments employed by the mind for the acquirement of knowledge. Not they but the mind itself observes. All observation is, in a sense, in answer to a certain hypothesis. No perception

is possible without interpretation which implies inference. There is, therefore, implicit inference involved in all observation.

But, from this very fact, a danger arises: our observation may be initiated by *bias*, and the facts observed by us may thus be wrongly interpreted. Sometimes we read our own thoughts into our perceptions. Sometimes the investigator may fall into another danger, *viz.*, inferring non-existence of a phenomenon from its non-observation. We shall speak of these errors under "Fallacies" in Chapter X.

3. **Experiment.**— This is another process accessory to Induction and its function is the accurate determination of causal connexions in phenomena under conditions over which we have control and which we can vary. In Observation it is not always possible to simplify the conditions and acquire a control over them.[1] But in Experiment we endeavour to produce a similar phenomenon under simpler conditions, which we can vary at will. Thus we can easily produce the seven colours of the rainbow by means of a spectrum, and obviously spectral analysis is much more practicable and much easier than the analysis of a rainbow. The rainbow may appear for a few minutes only: it will not wait for the completion of our observation or analysis, and we cannot produce it at will. But by means of an experiment with the Spectrum we can produce the same phenomenon and study it with ease and leisure.

Observation may be carried on sometimes even without any reference to any hypothesis, but Experiment is necessarily an answer to, or a verification of, a hypothesis.

[1]Sometimes Nature herself produces special conditions favourable to the study of a phenomenon. These are called *Natural Experiments*. For instance, an eclipse of the moon shows the shape of the earth to be round.

There must be some suggestion, or supposition, whose truth or falsity we may be called upon to discover by means of Experiment.

4. **Relation of Observation and Experiment.**—It is usual to distinguish Observation and Experiment as "Passive" and "Active" experience.[1] We shall presently show how incorrect this distinction is. We may refer here to the following famous quotation from Herschel's *Preliminary Discourse on the Study of Natural Philosophy*, pp. 76-77 :—

"To these two sources (Observation and Experiment) we must look as the fountains of all natural science. It is not intended, however, by thus distinguishing observation from experiment to place them in any kind of contrast. Essentially they are much alike, and differ rather in degree than in kind; so that, perhaps, the terms *passive* and *active observation* might better express their distinction; but it is, nevertheless, highly important to mark the different states of mind in inquiries carried on by their respective aids, as well as their different effects in promoting the progress of science. In the former we sit still and listen to a tale, told us perhaps obscurely, piecemeal and at long intervals of time, with our attention more or less awake. It is only by after-rumination that we gather its full import; and often, when the opportunity is gone by, we have to regret that our attention was not more particularly directed to some point which, at the time, appeared of little moment, but of which we at length appreciate the importance. In the latter, on the other hand, we cross-examine our witness, and by comparing one part of his evidence with the other, while he is yet before us, and reasoning upon it in his presence,

[1] "Observation is passive experience Experiment is active experience"—Stock, *op. cit.* p. 160.

are enabled to put pointed and searching questions, the answer to which may at once enable us to make up our minds."

Thus Observation and Experiment are compared as follows :—

OBSERVATION	EXPERIMENT
1. "Passive" experience.	1. "Active" experience
2. Under nature's conditions (natural).	2. Conditions under our own control (artificial).
3. Conditions invariable.	3. Conditions can be varied.
4. Conditions may never be repeated.	4. Conditions reproduced at will.
5. We are slaves of nature.	5. We are masters of nature.
6. The phenomenon to be studied can hardly be isolated.	6. The phenomenon to be studied can be isolated.
7. Has a wider scope.	7. Has a narrower scope.
8. Less precise and subtle than Experiment.	8. More precise and subtle than Observation.
9. From effects to causes.	9. From causes to effects.

Where experiment is possible it is decidedly superior to observation as an instrument of discovery. But unfortunately it cannot be applied to all departments of nature. For instance, in Astronomy, Geology, etc., we have more to watch the course of nature than to institute experiments. In sciences of the human nature also experiment has very little scope.

Experiment has, however, the following advantages over observation :—

1. We can vary the circumstances at will and produce several suitable instances of the phenomenon under study.

2. We can isolate and control the phenomenon by simplifying the conditions.

3. We can produce new phenomena similar to those found in nature.

5. **Observation Essentially Active.**- We have already alluded to the common distinction between observation and experiment as *passive* and *active* operations. It is said that in the former the mind is passive; it simply receives a certain information about the phenomenon under study, but in the latter it is distinctly active. Now, this distinction is doubtless erroneous. It is based on a false theory of knowledge, *viz.*, the passivity of the mind. The truth is, as psychology has convinced us, that the mind is never entirely 'passive.' It may be passive in the sense of 'assimilation', but there is no mental state in which the mind does not work. When we are observing a certain phenomenon the work of interpretation as well as apperception is going on all the while, which clearly points to mental activity. We may characterise pure sensations as entirely "passive", but in our adult life we never have these sensations: they are psychological abstractions. The actual units of our mental life are 'perceptions' and not 'sensations', and in an act of perception the mind is always active. Hence Observation which is of any use to science must be characterised as essentially active.[1]

Scientific Observation, as we have already said, is always selective and purposive, hence it must essentially be an active process. Besides, as Dr. Schiller puts it

[1] "The goal of Observation is to see a fact as a fact-under-law. ....To see a fact scientifically is to see it in the light of an idea. Observation expresses a form of scientific endeavour which can be satisfied only when the fact is observed as fulfilling some law. The merely passive assimilation of fact is only the first stage in the complete process of Observation. . . . We may observe just as passively with our fingers as we can with our eyes or ears. Observation is passive just so long as it is purely assimilative"— W. R. Boyce Gibson, *op. cit.* pp. 389, 393-394.

forcefully: "*Good* observation is anything but passive. It involves active watchfulness. It demands enormous concentration of the attention on the point of the inquiry, enormous indifference to, and ruthless abstraction from, everything else. It is therefore subject to the same risk as experiment, and as apt to go wrong, if misdirected. Indeed it is only another sort, or perhaps another stage, of experiment. In both we begin by changing the conditions experimentally before observing, even if in 'observation' the change is merely that of taking up an attitude of watchfulness towards certain objects. And conversely, experiment would be useless if it were not accompanied by observation."[1]

We conclude, therefore, that there is no such thing as purely passive observation, and even if it were possible it would be quite useless for scientific investigation. The difference between observation and experiment is one of degree only: the mind is active in both the operations.

6. **Positive and Negative Instances.**—Scientific investigation aims at the greatest possible precision and accuracy. Hence Causal Explanation requires the fulfilment of two sets of conditions (*a*) that a particular cause has always a particular effect, and (*b*) that in the absence of the particular cause, the particular effect does not come about, *i.e.*, this particular effect never occurs unless the particular cause also occurs. Thus if a phenomenon called E (effect) results from the cause C, the true cause will be that which satisfies :—

(*a*) that whenever C, then E.

(*b*) that whenever E, then C.

or that whenever not C, then not E.

Instances which illustrate (*a*) are called *Positive*

[1] Schiller, *op. cit.* pp. 338-339.

Instances, those illustrating (*b*) are known as *Negative Instances*[1]. They are sometimes called Positive and Negative *Experiments*.

Negative Instances may be distinguished from Exceptions The former *prove* a causal relation, while the latter *disprove* it. The two arguments may be compared thus—

NEGATIVE INSTANCE	EXCEPTION
Whenever C, then E. Whenever not C, then not E. ∴ C may be causally connected with E.	Whenever C, then E. Here C is, but E is not. ∴ C is not causally connected with E

Exceptions or Exceptional Instances are, if real, incompatible with the hypothesis we seek to establish and lead us to give up or modify such hypothesis. Sometimes *one* exception alone is sufficient to disprove our hypothesis. A real Exception compels us to so modify our hypothesis as to make it consistent with facts. The popular aphorism "*Exceptio probat regulam*"[2] when applied to Induction can only mean this: an exception "proves" the rule inasmuch as it requires us to modify the wrong hypothesis so that it may become compatible with fact. In this sense an exception *proves* the rule: otherwise, as we have shown, the legitimate function of Exception is to *disprove* a suggested hypothesis. It *indirectly proves* the hypothetical rule by *directly* disproving a wrong hypothesis.

[1] Negative Instances are also called "Blind Experiments" by chemists.

[2] In jurisprudence this maxim is strictly true, since the very existence of the specific cases exempted by the legislator from the operation of a certain law proves the existence of the law.

7. Rules for Observation and Experiment.—The following general directions may be helpful in Observation and Experiment :—

(1) It is necessary that the phenomenon to be studied should be isolated as far as possible. The irrelevant should be eliminated, so that the possibility of any disturbing influences may be avoided. In experiment we can always isolate the phenomena, but in observation we have to wait patiently for an opportunity when nature might do the same herself. We sometimes insist on repeated observation for the simple reason that nature does not present to us the situation as we need precisely. In experiment we are masters of the situation and can easily isolate the phenomenon.

(2) We should vary the circumstances as much as possible. Try the same phenomenon under varying conditions, and the possibility of error is greatly eliminated.

(3) We must always aim at precision in our observations and experiments. In experiment precision can be attained without much difficulty, but in observation it is more difficult. In order to insure it in the latter also, we must be on our guard against the faults known as non-observation and mal-observation, and should also eliminate the personal factor as much as possible. We must not read our own thoughts into our observation and must not confound what we *observe* with what we *infer*.

(4) In *quantitative* measurement where slight

inaccuracies in results are bound to occur, we must always make necessary corrections to bring the results as close to precision as possible.

(5) There are, in mathematical observations generally, errors which cannot be eliminated by a repetition of observations, *viz.*, *fixed*, *personal* and *causal* errors, which we must always endeavour to avoid[1]. There may be some fault in the instruments we use in our experiments, or we may be deceived by our senses or we may not be in a proper mood to make accurate observations or sometimes we may be led into hasty generalisations and may mistake the accidentals for the essential conditions.

(6) As far as practicable we should verify the results of observation by means of experiment. Observation should be viewed as only a stage in the complete development of scientific experiment. Mill wisely said: "Observation without experiment, and supposing no aid from deduction, can ascertain sequences and co-existences, but cannot prove causation." To prove causation we should be able to produce artificially the antecedent of the phenomenon we study and see if it unconditionally generates the effect.

[1] *Vide* Croke *op. cit.* p. 269

Summary

Analysis of the Given is the first essential step towards scientific explanation.

Observation and *Experiment* are two important accessories of Induction. Both are purposive and selective. Scientific Observation is essentially active, and the difference between it and Experiment is that of degree, not of kind. In Observation one cannot vary the conditions and isolate the phenomenon to be studied, in Experiment the conditions of observation are under our own control and amenable to interference. Observation has a wider scope than Experiment, but the latter is a more neat, subtle and precise instrument of scientific discovery.

Positive Instances and Experiments prove that whenever a certain cause occurs a certain effect follows, Negative Instances and Experiments prove that whenever such cause is absent the effect does not follow. Exceptions differ from Negative Experiments inasmuch as they *disprove* a suggested causal connexion.

Questions and Exercises

1. Compare the respective advantages of Observation and Experiment.

2. "Observation and Experiment (supposing no aid from deduction) can ascertain sequences and co-existences, but cannot prove causation" (Mill.) Examine.

3. What are the essentials of a truly scientific observation and a truly scientific experiment?

4. Distinguish Observation from Experiment. Is the difference fundamental? Show the dependence of Observation on previous knowledge, and in what sense it always involves inference.

5. When has Observation more advantages than Experiment? and why is Experiment usually more advantageous than Observation?

6. Describe the function of Experiment in scientific investigation. How far, if at all, can we be said to experiment (1) in Astronomy, (2) in Politics (3) in Psychology.

7. Account for the superiority of Experiment over Observation and mention the leading fallacies incident to Observation.

8. What are Natural Experiments? Give examples.

9. Distinguish between (1) Positive and Negative Experiments, (2) Negative Experiments and Exceptions.

10. On what facts is the popular maxim "Exceptions prove the rule" based? How far is it valid? Does it possess any scientific value?

CHAPTER VI.

MILL'S INDUCTIVE METHODS

1. **Inter-relation of Mill's Methods.**—Mill has formulated a number of methods by which causes and effects of a given phenomenon may be determined, *i.e.*, by means of which causal sequences may be discovered and proved. They are the rules which guide us in our causal inquiry, and are deducible from the very definition of Cause, as will be shown below. Mill calls them "Methods of Experimental Inquiry" or "Inductive (or Experimental) Methods." He speaks of *four* such methods, yet gives us *five* canons. These are, he further tells us, based on *two* fundamental principles: "The simplest and most obvious modes of singling out from among the circumstances which precede or follow a phenomenon, those with which it is really connected by an invariable law, are two in number. One is by comparing together different instances in which the phenomenon occurs. The other is, by comparing instances in which the phenomenon does occur, with instances in other respects similar in which it does not. These two methods may be respectively denominated the Method of Agreement and the Method of Difference."[1] Of the other three methods, one, *viz.*, the Joint Method of Agreement and Difference, is simply a combination of these two methods; while another, *viz.*,

[1] Bk. III. viii. 1.

the Method of Residues, is " in truth a peculiar modification of the Method of Difference ";[1] and the third, *viz.*, the Method of Concomitant Variations, may be identified either with the Method of Agreement or with that of Difference. Then, again, of the two fundamental methods, *viz.*, (i) Agreement, and (ii) Difference, the latter is said to be the more important......in fact the only important method......since the former is at best a method of *observation* and only *suggests* instead of *proving* the existence of a causal sequence : in Mill's own words, " it is by the Method of Difference alone that we can ever, in the way of direct experience, arrive with certainty at causes." Thus we observe that Mill looked upon the Method of Difference alone as the most fundamental method of discovering causal laws, and to it added four subsidiary methods.

Elsewhere Mill speaks of his Methods in the following terms : " The four methods......are the only possible modes of experimental inquiry, of direct induction *à posteriori*, as distinguished from deduction. These, with such assistance as can be obtained from deduction, compose the available resources of the human mind for ascertaining the laws of the succession of phenomena."[2] These laws, although known after Mill's name, were in no way Mill's original discoveries. They were borrowed from amongst the ' Nine Rules of Philosophising ' laid down by Sir John Herschel in his *Discourse on the Study of Natural Philosophy* (*vide* Sect. 145-158), with reference to which Mill says, that it is this book " in which alone of all books which I have met with, the four methods of induction are distinctly recognized, though not so clearly

[1] *ibid.* III. viii. 5.

[2] *ibid.* III. viii. 7.

characterized and defined, nor their correlation so fully shown, as has appeared to me desirable." [1]

2. **Statement of the Methods: Mill's Canons.**—We give below Mill's statement of the five Canons along with their symbolical formulas. As Mill's statements are more or less clumsy, we append improved versions[2] as well, which are much easier to follow :—

I. The Method of Agreement :

(a) Canon :—

Mill's Statement.	Improved Version.
If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon. [3]	If two events are observed to accompany each other... in succession or co-existence —they are (probably) causally connected. [4]

(b) Symbolic Formula :—

ABC followed by abc,
ADE ,, ,, ade,

∴ A and a are causally connected.

II. The Method of Difference :

(a) Canon :—

Mill's Statement.	Improved Version.
If an instance in which the phenomenon under investigation occurs, and an instance in which it does not occur, have every circumstance in	If the addition of an agent is followed by the presence, and its subtraction by the absence, of a certain event ; (other circumstances being

[1] *ibid.* III. vii. 1.

[2] For other improved versions see Mellone's *Introductory Text-Book of Logic*, Ch. IX., and Stock's *Logic*, ch. IX.

[3] These methods can be applied both for discovering *causes* of given effects, or *effects* of given causes ; hence Mill speaks of "cause (or effect)" in this and the other canons.

[4] "The probability increases with the number and variety of the instances"....Mellone, *ibid.*

Mill's Statement.	Improved Version.
common save one, that one occurring only in the former; the circumstance in which alone the two instances differ, is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.	the same) the agent is causally connected with the event.

(b) Symbolic Formula :—

ABC—abc.

BC—bc.

∴ A and *a* are causally connected.

III. The Joint Method of Agreement and Difference :[1]

(a) Canon :—

Mill's Statement.	Improved Version.
If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance; the circumstance in which alone the two sets of instances differ is the effect, or the cause, or an indispensable part of the cause, of the phenomenon.	Whatever is present in numerous observed instances of the presence of a phenomenon, and absent in numerous observed instances of its absence, is (probably) connected causally with the phenomenon.

(b) Symbolic Formula :—

$$\left.\begin{array}{l}\text{ABC—}a\text{bc}\\ \text{ADE—}a\text{de}\\ \text{AFG—}a\text{fg}\end{array}\right\}\text{ positive instances ;}$$

$$\left.\begin{array}{l}\text{BMN—bmn}\\ \text{DOP—dop}\\ \text{FQR—fqr}\end{array}\right\}\text{ negative instances ;}$$

∴ A and *a* are causally connected.

[1] This method is also known as the *Indirect Method of Difference* or the *Method of Double Agreement.* Its improved version is given after Mellone.

IV. The Method of Concomitant Variations :—

(a) Canon :—

Mill's Statement.	Improved Version.
Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation.	If two phenomena always vary together, probably they are causally connected [1]

(b) Symbolic Formula :—

ABC—*a*bc,

A_2 BC—a_2 bc,

A_3 BC—a_3 bc,

∴ A and *a* are causally connected.

V. The Method of Residues :—

(a) Canon :—

Mill's Statement.	Improved Version.
Subduct from any phenomenon such part as is known by previous inductions to be effect of certain antecedents, and the residue of the phenomenon is the effect of the remaining antecedents.	If we subtract from a phenomenon those elements which are due to known causes, the residue will be the effect of an unknown cause.

(b) Symbolic Formula :—

ABCD is the *known cause* of *a*bcd.
B ,, ,, ,, b.
C ,, ,, ,, c.
D ,, ,, ,, d.

∴ A and *a* are causally connected.

Before we consider any concrete examples illustrative of the application of these methods, and their limitations, we shall deal with an important consideration respecting the nature of the methods and the part played in them by Elimination.

[1] Mellone adds : " Other circumstances remaining the same or varying independently." This clause makes the sense more clear.

3. **Inductive Methods as Rules of Elimination.**—We have observed that the last three of Mill's five methods are simply the combinations of the two methods of *Agreement* and *Difference*. These two methods are called by Mill methods of *Elimination*: "The Method of Agreement stands on the ground that whatever can be eliminated is not connected with the phenomenon by any law. The Method of Difference has for its foundation that whatever cannot be eliminated is connected with the phenomenon by a law."[1] Elimination is defined by Mill as "the operation which has been understood since the time of Bacon to be the foundation of experimental inquiry...... namely, the successive exclusion of the various circumstances which are found to accompany a phenomenon in a given instance, in order to ascertain what are those among them which can be absent consistently with the existence of the phenomenon" (*ibid*). In other words, Elimination is the process of *exclusion, i.e.*, by which we exclude one by one the irrelevant circumstances and thereby discover the relevant circumstances constituting the cause of an effect or the effect of a cause; and Mill's Inductive Methods are Methods of Elimination.

The principles or grounds of Elimination can easily be derived from the very definition of Cause.[2] Cause is that without which a phenomenon would not occur—in Mill's words "the invariable and unconditional antecedent." If that is so, it follows immediately that—

1. That is not the cause of a phenomenon in the absence of which the phenomenon occurs.

[1] Mill, *op. cit.* III. viii. 3.

[2] cf. Joseph. *op. cit.* pp. 403-404; Creighton, *Introductory Logic*, New York, 1909, p. 238.

2. That is not the cause of a phenomenon in whose presence the phenomenon fails to occur.
3. That is not the cause of a phenomenon, which varies when it is constant, or is constant when it varies, or varies in no proportionate manner with it.[1]
4. That is not the cause of a phenomenon which is known to be the cause of a different phenomenon.

These are the **four principles or grounds of Elimination.** They guide us as to how we are to exclude all those irrelevant circumstances of a phenomenon that do not satisfy the conditions of a cause. We entirely agree with Joseph in taking these rules of Elimination as the basis of Mill's Canons. Mill's Method of Agreement is based on the first ground; his Method of Difference on the second; his Joint Method of Agreement and Difference on the first and the second combined; his Method of Concomitant Variations on the third; and his Method of Residues on the fourth ground of Elimination.[2] The principles are simple enough and their application too is by no means difficult, provided we have got the situation we require in which we can distinguish the circumstances under which a phenomenon occurs and those under which it fails to occur. But it is just that which is extremely difficult, and, as, Joseph says, " inductive

[1] This principle obviously follows from the idea of *succession*, *viz.*, that energy gained by one phenomenon is lost by another—which implies succession ; or from the Equality of Cause and Effect. cf. Carveth Read, *op. cit.* pp. 195-197.

[2] Cause is used here in its strictly scientific sense of a reciprocating cause ; in the case of a non-reciprocating cause other principles will be necessary. cf. Joseph. *op. cit.* footnote on p. 404.

reasoning is in form very simple; but the discovery of the proper premisses is very hard." [1]

We hold Elimination to be the very soul of inductive inquiry. Such inquiry, as we know, aims at the establishment of causal relations between events. Events may happen ever so many times; their causal connexion is not revealed by itself but has to be discovered by our mind. This can only be done by carefully analysing the phenomena under investigation, sifting and excluding all those elements which do not fulfil the conditions of a cause. By this process of Elimination all the alternative hypotheses that fail to satisfy the requirements of the causal relation are rejected, and by means of their rejection we discover the cause. This view is admirably expressed by Joseph :—

"The essence of inductive reasoning lies in the use of your facts to disprove erroneous theories of causal connexion. It is, as Mill himself asserts, a process of *elimination*. The facts will never show directly that *a* is the cause of X; you can only draw the conclusion, if they show *nothing else is*....You do not discover what is the cause, except by eliminating the alternatives. Yet it is very often impossible to do this completely; nevertheless the nature of your reasoning is precisely the same, when you are left with the conclusion that the cause is either *a* or *b* or *c*, as if you had been able to eliminate *b* and *c* also, and so determine that the cause is *a* (p. 395). The essence of inductive inquiries is the process of elimination. The reasoning is disjunctive. And the character of the reasoning is unaffected either by the completeness of the elimination, (*i.e.*, the fact that there are no *alternatives* left in the conclusion) or by the ground of elimination used (p. 396)...Inductive conclusions are

[1] *op. cit.*, p. 406.

established disjunctively by the disproof of alternatives (p. 408)......The inductive proof of a conclusion rests on excluding alternative explanations." (p. 415).

This seems to us the clearest statement of the function of Elimination and the part played by it in inductive reasoning. We hold with Joseph that **Induction is essentially a Method of Elimination** and that inductive conclusions are established through the *disproof* of the alternatives that fail to satisfy certain conditions.

Exception is, however, taken to this view by some logicians, among whom is Boyce Gibson.[1] His main contentions are :—

(1) That only the Method of Agreement and not that of Difference can be called a Method of Elimination.

(2) The Method of Difference is emphatically not a method of *logical* Exclusion or Elimination, but of *physical* Exclusion. Its essence is not the elimination of the non-cause, but the establishment of the cause.

(3) Mill's method of Concomitant Variation has a *positive* character, while the third ground of elimination on which it is said to be based is of a *negative* character.

(4) Except the Method of Agreement, Mill's inductive methods are the positive verification methods. It is gratuitous to suppose that verification of a theory always rests on the disproof of its rival theories; it may—in fact, it does—rest *essentially* on the positive value of the theory as a means for systematically explaining the relevant facts, and disproof is only a

[1] *vide* Gibson, *op. cit*, pp. 413-422.

subsidiary and supplementary operation, in no sense of primary importance.

To these contentions may also be added another made by Joyce,[1] who maintains—

(5) That an argument drawn by the process of elimination remains for ever inconclusive. Our aim should be not merely to eliminate those antecedents which are not the cause; we must have positive grounds for asserting that the effect proceeds from such and such a fact and from no other.

We shall now answer very briefly each of these contentions in their serial order :—

(1) There is no reason to suppose that the Method of Agreement alone is a method of Elimination. Mere statement or conjecture is no proof. Mill himself explicitly tells us that all his methods "are methods of *elimination*. The Method of Agreement stands on the ground that whatever can be eliminated, is not connected with the phenomenon by any law. The Method of Difference has for its foundation, that whatever cannot be eliminated, is connected with the phenomenon by a law. The Joint Method is a double employment of the Method of Agreement. The Method of Residues is......a peculiar modification of the Method of Difference," (III. viii. 3-5) and the Method of Concomitant Variations is "but a modification either of the Method of Agreement or of the Method of Difference" (III. xxii. 4). Thus each of these methods seeks to establish the relation of causality by eliminating parts of a complex phenomenon. Mill's own statement leaves no doubt on the point.

(2) Hence it is entirely arbitrary to suppose, as Boyce Gibson does, that with regard to the Method of Difference Mill used the term 'elimination' in the

[1] *vide* Joyce, *op. cit.* p. 331.

sense of '*physical* exclusion.' The truth is that elimination is a mental process, and does not mean physical exclusion. By this process our mind guides us in the discovery of causes or effects, since the *relation* of causality cannot itself be perceived From the quotation given above it does not appear at all why Mill should abruptly use the term in an entirely different sense, when speaking of the Method of Difference. That he does so is merely an assumption, which is not supported by any arguments Again, to contend that the Method of Difference does not propose to eliminate the non-cause but to establish the cause seems to us like putting the cart before the horse. We emphatically hold that the cause cannot be established except by eliminating the non-cause: there is no other way. Otherwise, negation will have no part to play in reasoning. We might examine a number of positive cases to verify a cause, but even a single negative instance would be sufficient to disprove our theory Hence the proper way is to attempt eliminating gradually all those factors which are non-causes, and then to discover the cause. Such cause could then be deductively verified.

(3) There is no wonder whatsoever in Mill's Canon of the Method of Concomitant Variations being of a *positive* character, since all these rules aim at the discovery of a causal relation. But why should it be necessary for its ground of elimination also to be of a *positive* character? How can a principle of *elimination* have a positive character? Elimimination implies negation, and it is through negation that the positive aim of the discovery of a cause is satisfied. Boyce Gibson has therefore been struck by an *illusory* opposition. We hold that there is no discrepancy on the point between

the Method in question and its ground of elimination.

(4) If Mill's Methods are "the positive verification methods," why treat the Method of Agreement as an *exception*? For, by doing so, don't you weaken your own contention, as three of the remaining four methods do in same way involve that of Agreement? Besides, the main contention is itself untenable. We do not deny that the ultimate aim of the inductive logician is to establish a cause rather than disprove a non-cause, but the Methods under discussion are corollaries deduced from the scientific conception of Cause itself, and as such lay down practical rules for the discovery and proof of cause (or effect). You cannot establish any theory until you have been able to disprove its rivals. This function of Elimination can hardly be questioned. We maintain that it is in this spirit that the Methods were formulated, and that they would be absolutely futile if elimination did not play its part in them.

Boyce Gibson proposes to substitute Bosanquet's Method of Analysis for the Method of Elimination, and states the latter's view as follows: [1]—Induction is the progressive 'moulding of Hypothesis' through a process which is a purifying by exceptions and a limiting by negations. In this process we have central importance attached to the positive progressive elaboration of causal connexions, with a clear recognition of the part played by negation, and in particular by elimination.[2] Now, so far as Bosanquet's view is concerned—which is quoted with approval by Boyce Gibson—we fail to see any essential difference with our position. If Induction is

[1] *vide* Bosanquet, *Logic* vol. II ch. iv p. 117 and ch. v, pp. 166-167 quoted by Mr. Boyce Gibson in support of his contention.

cf. Gibson, *op. cit.*, p. 420.

the progressive moulding of Hypothesis, its end can only be realised by means of Elimination. We do not know of any other way in which Hypothesis could be "moulded" than by the gradual exclusion of the irrelevant or the non-cause. This truth is recognised by Bosanquet himself when he describes the process as "a purifying by exceptions and a limiting by negations." Is the *positive* verification of Cause possible without such operation? And is it also not admitted that "the positive, progressive elaboration of causal connexions" is based on a clear "recognition of the part played by negation, and in particular, by elimination"? Bosanquet's view therefore supports *our* position rather than the other. The only difference may be that he shifts the emphasis on the ultimate aim of the inductive inquiry—which is certainly *positive*; while, concerned as we are more directly with Methods, we prefer to emphasise the nature of the process through which alone a causal relation can be established.

(5) As to Joyce's contention, the above statements suffice to refute it. We may only add that no argument could be more inconclusive than that which proceeds without elimination. A hundred and even a thousand instances may not succeed in *proving* a causal connexion, while one instance alone may suffice to *disprove* it. To assert that "an argument drawn by the process of elimination remains for ever inconclusive" is, therefore, to make a statement that is its own refutation.

Our doctrine that Elimination is the essence of Induction gains further support from an entirely independent source, *viz.*, Hindu Logic. There the principle of Elimination is clearly laid down, *e.g.*, in Kanāda's Sūtra: "कारणाभावात् कार्याभावः" (I. 2. 1), which means:

"From the non-existence of cause is the non-existence of effect." This implies that in order to determine the cause of a phenomenon we should begin by negating or eliminating those circumstances without which it would nevertheless exist (यत्र कारणाभावात् कार्यभावः) and those in whose presence it would not exist (यत्र कारणाभावात् कार्याभावः).[1] These principles are the same as the grounds of the Method of Agreement and that of Difference. We are also told in Hindu Logic that the establishment of a universal connexion (व्याप्ति) between cause and effect is based on our *disproving* the connexion with anything else (अन्यस्मिन्नसंबंधः). The principle of Elimination also follows from the general notion of Cause as ' यत्सत्वे यत्सत्वं, यदभावे यदभावः ,' *viz.*, ' That whose existence produces the effect, and whose non-existence produces the non-existence of the effect.' That the positive verification of Cause is impossible without the exclusion of the non-cause is evident from the text : "सा (व्याप्तिः) च व्यभिचारादर्शने सति सहचार दर्शनेन गृह्यते"[2] In the proposition ' where there is smoke, there is fire,' the co-existence (सहचार) of ' smoke ' and ' fire ' is proved by the 'non-perception of exceptions ' (व्यभिचारादर्शन), *i.e.*, by disproving the co-existence of ' smoke ' with any other cause (हेतु) The locative singular सति is important as it indicates that elimination must necessarily serve as the basis for the

[1] Kanāda adds in the following sūtra : "न तु कार्याभावात् कारणाभावः " (I.2-2), *i.e.*, the non-existence of cause does not follow from the non-existence of effect.

[2] *vide.* The *Vedāntaparibhāsha*, II. 4. This explains further how सहचार (co-existence) of हेतु and साध्य is recognised.

establishment of cause. Besides, it is well-known how great importance is attached to Elimination (व्यतिरेक) and what prominent part is played by Negation (अभाव) in Hindu Logic. It is, therefore, superfluous, to dwell any longer on this aspect of the question.

We might also mention that after watching very carefully the way in which little children enquire about the cause of several phenomena they come across, we find that elimination is instinctively present in their arguments as well. If you tell them " I shall not take you out for a drive this evening because it is raining," you will invariably be met with the query " but if it does *not* rain," and you are compelled to say "then, of course, I shall take you out." You say " I will punish you if you will break this toy "—and at once the little one would say " if I do *not* break it." Such examples can easily be multiplied. We do not mean that such like simple statements illustrate the application of Mill's fundamental method, but that the child-consciousness and its power of arguing develop through *negation*, and with the gradual evolution of the child-mind, elimination comes into evidence more and more. This fact lends additional support to our doctrine.

4. **The Method of Agreement.**

(a) *Examples*:—

(1) Heat expands a bar of iron; it also expands a bar of silver; also a bar of lead, copper, brass, etc. Therefore heat expands metals. The phenomenon under investigation is the expansion of metals. Heat is the one circumstance present in the antecedents of the instances, and is, therefore, the cause of the phenomenon.

(2) I take my breakfast and begin vomiting after a few minutes. What is the cause? I recollect

that some weeks ago I had taken sour milk and begun to vomit afterwards, this time also I had taken sour milk; hence taking sour milk is the one common circumstance present in the various antecedents of the two occasions, on which the phenomenon occurred and is therefore its cause.

(3) Three white rats in iron cage were left under the sun for a couple of hours. On returning home I found them all dead. I wondered how they all died. Next time I again kept two such rats in the same place and discovered that they expired themselves I gathered that their having been put under the sun caused their death.

(4) I was up last night till late hours, busy with my studies, and in the morning I felt drowsy and feverish. I remember about a month ago I had been to the theatre one night and returned very late; the next morning I had the same feeling of drowsiness, etc. On another previous occasion I had attended a marriage-party and was compelled to remain there till midnight. On getting up early in the morning I felt feverish. Now, the phenomenon under investigation is my feeling of drowsiness and feverishness. It may have been caused by a number of things but in all the above instances the only common circumstance is my keeping up late at night, which should therefore be taken as the cause.

(b) *Its Limitations and Criticism.*

(i) The Method is based on the assumption that an effect has only *one* distinct cause and is not the result of an inter-mixture of effects of several antecedents. Jevons states the formula for the discovery of the cause of a phenomenon by this method as—"The sole invariable antecedent of a phenomenon is probably its cause."

(ii) It assumes the existence of one common circumstance in a number of instances, and from its

symbolic formula it is no doubt evident that such common circumstance may be separated from the rest. But actual facts are not such as to be formulated in symbols. The state of things presupposed by the Method does not actually exist. There is a great complexity of phenomena in nature. The common circumstance exists in conjunction with various other circumstances, and can only be separated by analysis which is by no means an easy task.

(iii) It is purely a Method of Observation.—We observe a number of instances in which a given phenomenon occurs and try to ascertain the only one relevant and important circumstance common.[1] It is not a method of *mere* agreement[2] but of *single* agreement. The general distinction between a Purely Observational Method and an Experimental Method is that while the former proceeds from effect to causes, the latter proceeds from causes to effects. Boyce Gibson formulates this distinction more precisely as follows:—"Where the start is made from effects, *i.e.*, from facts or events viewed in the light of a causal interest—and causal explanations are tentatively formulated without any attempt to verify them by appeal to positive and negative instances, the Method is Purely Observational. Where, on the other hand, both positive and negative instances are used, with a view to the verification of suggested causal connexions, the method is Experimental."[3]

[1] The common circumstance selected must be 'relevant and important,' as otherwise the number of irrelevant and unimportant of such circumstances is infinite, and then no practical application of the method would be possible.

[2] cf. also Gibson, *op. cit.*, p. 396.

If it were so, it could be founded on simple enumeration, instead of elimination.

[3] *op. cit.*, p. 401.

(iv) Being a purely Observational Method the inference yielded by it cannot claim more than tentative certainty, until it is confirmed by the use of negative instances. For that reason we should say 'the common circumstance is *probably* its cause,' if we want to be precise. This method, therefore, can at best *suggest* a causal connexion but cannot *prove* it. Sometimes it fails to suggest even a causal *connexion*. It may mistake mere concomitance for a causal connexion. It is the method of proof "for all conjunctions whatsoever—whether Causation or Co-existence" (Bain, p. 52). For instance, when we see the mounted Police stopping general traffic in the streets of Calcutta, we expect the Governor's Car to follow. Here there is no causal connexion between the two facts. Thus no safe generalisation can be based on this Method taken by itself.

(v) This Method is vitiated by the Plurality of Causes. We cannot lay down with *certainty* the only or necessary cause of a given phenomenon; we can only say that a certain antecedent is *a* cause, not *the* only cause of the phenomenon. There may, for instance, be as many as ten causes to produce madness; and we cannot ascertain *the* cause of the madness of a particular person by means of this Method. It must be clearly understood that the term 'cause' is used in its popular sense in the application of the Inductive Methods, hence the Plurality of Causes is a legitimate obstruction in the way of a successful working of this Method. But at the same time it is easy enough to discover that this difficulty is mainly due to our own superficial and vague analysis. If we are careful enough in sifting the relevant from the irrelevant the chances of our failure are greatly reduced. To counteract the defect due to the plurality of causes, it is necessary to extend our investigation over a large

number of instances. The force of this method lies in the number and variety of the instances we observe, since it is only then that the chances of our failure to eliminate the circumstances that are not common to *all* instances are counteracted. Thus Mellone's statement of the First Canon is significant: "When observation shows that two events accompany one another (either simultaneously or in succession); it is probable that they are causally connected; and the probability increases with the number and variety of the instances."[1]

5. **The Method of Difference** :—

(a) *Examples* :—

(1) A man used to taking two meals a day takes a heavy lunch one day. His subsequent illness is ascribed to the additional meals, which his system could not evidently digest.

(2) A blue litmus paper immersed in an acid is changed into red The change of colour is due to the action of the acid. Here evidently the phenomenon under investigation is the change of colour; and it is present in the instances in which the action of an acid is present, while it is absent when the action of acid does not take place. The two instances agree in everything except in the circumstance, the action of the acid.

(3) You put a little spirit in a spirit-stove and light it. The spirit is consumed but the stove doesn't burn. You now pump it, and the blue flame appears with a roaring force. You therefore ascribe the burning of the stove to the pumping action. Without such action the flame did not appear; with this action it did appear. Hence it is the one circumstance in which the two instances do not agree, and which has therefore brought about the difference.

[1] S. H. Mellone, *op. cit.*, p. 271.

(4) While taking your breakfast you suddenly receive the news of the death of a dear friend. Your countenance changes at once, you leave off your breakfast, go into the bed-room alone, and tears flow from your eyes spontaneously. All this action is due to the receipt of the unhappy news.

(5) You hold a cigarette in your mouth, but cannot smoke it unless you light it. Hence it is the lighting of the cigarette which enabled you to smoke it.

(6) You load a pistol and hold it in your hand. It does not fire. You now pull the trigger, and out goes the shot. Hence the pulling of the trigger, other circumstances remaining the same, was the cause of the firing of a shot by the pistcl.

(7) You enter your room at night: it is all dark. You find your way to the switchboard and switch the current or. Immediately the whole room is lighted. The turning of the switch caused the lighting up of the room.

(8) About 60 lights and 12 fans are on in a big bungalow and great festivities are going on. Some one, out of ignorance or amusement, turns the main switch down, with the result that all lights disappear and all fans stop.

(9) You go to a doctor complaining of constipation and fever. He prescribes a certain purgative. Three hours after taking the purgative you feel quite yourself again; all fever and constipation have disappeared. The purgative is the cause of your cure.

(10) I have taken a long walk and feel very thirsty. I take a glass of water and at once my thirst is quenched.

(11) " When a man is shot through the heart, it is by this method we know that it was the gunshot which

killed him: for he was in the fulness of life immediately before, all circumstances being the same except the wound " (Mill).

Thus, it is obvious that there must be two and only two instances of the phenomenon under investigation. They are each of them a complex sequence but differ by a single sequence, which is *present* in the one instance *absent* in the other

(b) *Its Limitations and Criticism* :—

(i) This method is most commonly used in our every-day life. In Mill's words, it is " a logical process to which we owe almost all the inductive conclusions we draw in early life." Mill regards this Method as *the experimental method par excellence*, the only one by which " we can ever, in the way of direct experience, arrive with certainty at causes." It gives us " rigorous certainty."

(ii) It is essentially a method of Experiments. It compares a *positive* instance with a *negative* instance in order to find out that there is no other difference between the two instances except the presence of the supposed cause in one and its absence in the other And this cannot be ascertained by observation. Nature is not our slave. She is not under any necessity to present to us a state of things which will suit our purpose and requirements. Hence we have to produce our two instances by experiment, one after the other, and it is only then that the one essential respect in which the two instances differ can be traced.

(iii) For the successful working of this Method it is necessary that we should introduce or remove only *one* condition at a time. Every phenomenon is a complex whole, and our analysis attempts to isolate its various conditions or circumstances. Unless we change *one* circumstance at a time, we are likely to be baffled in our inquiry by the inter-

mixture of effects. If we vary *two* conditions at a time, it might result in the Intermixture of Effects or the effect of one may be neutralised by that of the other.

(iv) It is desirable that change should be introduced as rapidly as possible, otherwise the effect may mix up with other changes, and no definite inference will result.

(a) *Examples*:—

(1) I observe that whenever I take a cup of tea after dinner I do not feel inclined to retire to bed early. I therefore presume a causal relation between the two facts. This presumption is further strengthened if I find that whenever I do not take tea after dinner, I feel an inclination to sleep. Evidently I connect causally the taking of tea after dinner with no inclination to sleep early.

(2) I observe that whenever I take fish and eggs I am constipated: I infer that constipation is caused by that particular diet. But this inference is confirmed and my conviction is strengthened if I find that whenever I avoid taking fish and eggs I do not complain of constipation.

(3) Grapes grow in abundance on the soil of Afghanistan. I do not find them anywhere in Bengal or Bombay. Hence my belief is strengthened that there must be something in the soil of Afghanistan favourable to the growth of grapes.

(4) The formation of dew: "It appears that the instances in which much dew is deposited, which are very various, agree in this, and, so far as we are able to observe, in this only, that they either radiate heat rapidly or conduct it slowly: qualities between which there is no other circumstance of agreement, than that by virtue of either, the body tends to lose heat from the surface more rapidly than it can be restored from within. The instances, on the contrary, in which no dew, or but a small

quantity of it, is formed, and which are also extremely various, agree (so far as we can observe) in nothing except in *not* having this same property. We seem, therefore, to have detected the characteristic difference between the substances on which dew is produced, and, those on which it is not produced." (Mill, III. ix. 3.) In this way the requisitions of the Joint Method have been realised.

(5) Whenever I come down and stay in Bengal I suffer from Indigestion. The presumption, therefore, is that my Indigestion is due to the climate of Bengal. This belief is further confirmed if I get rid of my indigestion whenever I am away, *e.g.*, whenever I visit the Punjab or Kashmir and stay there for sometime.

(b) *Its Limitations and Criticism.*

(i) There are two series of instances, in the one the causal sequence is present, while in the other it is absent. Obviously the two sets taken together resemble a good deal the Method of Difference.

(ii) But the real nature of the Method is aptly expressed by the title " the Method of *Double* Agreement," for, as Mill has pointed out, it consists in a double employment of the method of (single) Agreement, each proof being independent of the other and corroborating it. It is a peculiar modification of the Method of Agreement.

(iii) Rightly, as Mill observes, this method is a great extension and improvement of the method of Agreement, but it likewise falls short of proving causation. It does not rise up to the cogency and exactness of the Method of Difference. At best it cannot do more than *suggest* the *likelihood* of a causal connexion.

(iv) Although it leads to greater probability than the Method of Agreement, yet it is not quite free from the characteristic fault of the latter. Even the

double employment of Agreement fails to eliminate the defect of the Plurality of Causes. The phenomenon under investigation may show that a given effect may *on any given occasion* be brought about by a plurality of causes.[1] The agreement in presence as well as that in absence only *suggests* a causal presumption, but is not so exact or complete as to *prove* causation.

(v) It is like the Method of Agreement, an essentially observational method. It does not require us to prepare our instances under artificial conditions, but takes account of such as are available by observation.

7. **The Method of Concomitant Variations** :—

(a) *Examples* :—

(1) On a dull and sultry day in summer I do not feel disposed to eat anything. On the other hand, on a cool and breezy day my appetite is much in evidence. By the Method of Difference it may be proved that the cold is the cause of my appetite for food. But if we find that as winter sets in my appetite gradually increases, and that during the summer months it again decreases, we apply the Method of Concomitant Variation and infer that the increase or decrease of my appetite for food is due to an increase or decrease of the cold.

(2) Suppose there are four electric bulbs of 50 c.p. each fixed up in my study. I switch on one light, the room is lighted; I put on the second light, the light is increased; I do so with the third, the light is still further increased; and with the fourth on, it becomes very brilliant. If I were to measure the gradual increase in the intensity of lights (by means of a Photometer) I would find that the increase in such intensity was determined by the increase in

[1] "The reason is that the effect to be accounted for is as unprecisely conceived in the second application as in the first"...Gibson. *op. cit.* p. 400.

the number of lights used. Thus by the Method of Comcomitant Variation I could establish a quantitative relation between the amount of electric light and the degree of illumination of my room.

(3) I order a jug of hot water. The servant heats a litre of water over a spirit-lamp and brings me a jugful in about 10 minutes. But on another occasion when I want hot water for my tea, which is getting cold, I cannot wait so long; I order him to fetch me the same amount of hot water within some five minutes. He succeeds in doing so, but only by using two spirit-lamps of the same power. The inference is that the rise of temperature of the water in each case is due to the corresponding increase in the heat applied.

(4) The more you use your physical or mental powers, the more developed they become. Therefore, the use or exercise of a power is the cause of its development.

(5) We fix an electric bell on to an air-pump under the receiver. You can hear the bell ringing. It will keep on ringing so long as the electric current is on. Now, without breaking the current, begin to work the air-pump. With each stroke of the pump some air will be exhausted from the receiver, and the sound of the bell will gradually become fainter, until at last it will altogether cease, when no air is left in the receiver. If the air is allowed to pass back into the receiver, the sound of the bell begins to be heard, it becomes clearer and clearer till the original intensity is resumed. Thus we prove that there is no sound in a vacuum.

(6) This Method is also illustrated in determining the relation between the ebb and flow of the tides and the waxing and waning of the moon.

(7) The weight of a body varies directly as its mass and inversely as the square of its distance from the centre of the earth. That is to say (a) as the mass

of a body increases, its weight also increases, and (b) as the distance of a body from the centre of the earth increases, its weight decreases.

(8) The more I attend to an idea, and the more often I repeat it, the greater is its retention in memory.

(9) The rise and fall of the mercurial column of a thermometer varies with the increase and decrease of the temperature of the medium to which it is applied.

(10) Mill's example of the first law of motion—that all bodies in motion continue to move in a straight line with uniform velocity until acted upon by some new force. We cannot prove this law by the Method of Difference, since it fails to overcome the difficulty of *permanent causes*, (*i.e.*, causes whose agency cannot be eliminated, *e.g.*, gravitation.) Nature does not present any instance of perpetual motion, but the various obstacles, *e.g.*, friction, atmospheric resistance, etc., encountered by a moving body, may be taken into consideration. We cannot, however, produce an instance in which these obstacles would be entirely absent—in other words, the method of Difference is inapplicable. All we can do is to *modify* what cannot be altogether *excluded*, the modification of a condition meaning according to Mill, "change in it, not amounting to its total removal."[1] If we modify the obstacles to perpetual motion, *i.e.*, diminish in this way the resistance to a moving body, we find a corresponding increase in the time for which a motion

[1] "It is a methodical modification of this kind which constitutes the *Method of Concomitant Variations;* and the most striking application of this method, as Mill points out, takes place in the cases in which the Method of Difference is quite inapplicable, *e.g.*, in establishing laws of heat, gravitation, friction. We here make a series of partial experiments, in which we proceed by a gradual quantitative modification of the constituent which cannot be wholly withdrawn,"—Gibson, *op. cit.*, p. 405.

continues. By such like experiments alone can the law be established.

(b) *Its Function, Limitations and Criticism:—*

(i) The Method is an extension of the Method of Agreement or the Method of Difference, or of both, as the case may be. The inference drawn by this method is therefore affected by the limitations of those two methods, and its principle does not essentially differ from them.

(ii) It cannot *prove* a causal relation, particularly when the variation cannot be exactly measured. Moreover, the two phenomena varying together according to some numerical relation may not be related to each other as cause and effect. They may both be joint-effects of a single cause.

(iii) It is a useful *supplement* to the *qualitative* methods, and is usually employed to determine a precise *quantitative* relation. We first ascertain by the Method of Difference that a certain cause produces a certain effect, and then use the Method cf Concomitant Variations to determine the *quantitative* relation between them.

(iv) There is a particular danger in the employment of this method. One is tempted to imagine that the Concomitant Variation which holds good within certain limits will always hold good. But such a universal law cannot be framed. Variation is not always continuous. For instance, (a) As we increase the temperature of water at the sea-level continuously from 0°C. we mark a corresponding increase in its density up to 4°C, but after that point, although the temperature may be continuously increased up to 100°C, the density decreases; (b) In tropical climate, the greater the rain-fall the greater the wheat or rice crop; but if the rain-fall is excessive, the crop fails altogether. Thus variation holds good within some definite limits.

(v) Where the Method of Difference cannot be applied, this Method can be applied to determine the *qualitative* or the *quantitative* relations between two or more circumstances of a phenomenon, when they cannot be separated from it. In such cases this method is particularly useful and is, in fact, the only method that can be employed.

8. **The Method of Residues** :—

(a) *Examples* :—

(1) In a room usually lighted by 4 electric bulbs, of 50 c.p. each, an additional light-point is fixed, to which is attached a bulb of 100 c.p. When all the five lamps are lighted, the illumination of the room is much more intense. Subducting from this intensity the degree of illumination I had so far with 4 lamps, I can infer by the Method of Residue that the remaining degree of illumination is caused by the fifth lamp, newly put.

(2) Subducting from the phenomena of living things those effects that are due to physical or chemical forces, we have to account for those which are left behind and this leads us to the inference of vitality as their cause.

(3) By the same method is proved the existence of the mind; the phenomena of the mental world cannot be explained in terms of matter. Subducting all that can be so explained, a residue is left behind, which cannot be accounted for except on the assumption of a mind.

(4) A and B can build a wall in 10 days; A alone can build it in 15 days. We can find by this method how long it would take B to do the same work.

(5) You ascertain the weight of a tin of *ghee* by first weighing the *ghee* and the tin, and then subtracting the weight of the empty tin, known already.

(6) We can find out how much of the spring tides is due to the attraction of the Sun. By previous inductions we know the average height of the tide

due to the moon. Subtracting this from the whole height, we get the remaining part of the spring tide due to the attraction of the sun.

(b) *Its Function, Limitations and Criticism:—*

(i) Mill regards this method as a peculiar modification of the Method of Difference.

(ii) This method can only be applied when we already know a great deal, *i.e.*, it rests on previous inductions and consequently partakes of a *deductive* character.

(iii) The analysis of the phenomena effected by this method is *mental* rather than *actual*.

(iv) The method can be applied in cases both of observation and experiment. In experimental cases it is a *quantitative* method, (*e.g.* in chemical analysis) In cases of observation it is a *qualitative* method and seeks to find out a cause *qualitatively* adequate to account for the observed effect.

(v) It is found particularly useful in Astronomy.[1] For instance, the planet Neptune was discovered in 1846 by Adams and Leverrier (working independently) by observing the residual effects of the motion of Uranus. After allowing for the perturbing influence of *known* planets and the attraction of the Sun, a residual effect was noticed as due to the perturbation of some unknown planet, which was found to be Neptune.

(vi) By the use of this method remarkable discoveries in Chemistry (where exact measurements are as necessary as in astronomy) have also been made For instance, *Argon* was discovered as a constituent part of atmosphere by Lord Rayleigh and Professor Ramsay in 1894. It was found that *nitrogen* extracted from the atmosphere was 1 per cent. heavier than its usual density. Various

[1] "Almost all the greatest discoveries in astronomy have resulted from the consideration of residual phenomena of a quantitative or numerical kind."—Herschel.

hypotheses were put forward to explain this residual phenomenon, and at last the new chemical element, known as *Argon*, was discovered.

(vii) This method is used as a "finger-post to the unexplained." It is thus a method of *discovery* rather than of *proof*; in other words it is a source of hypothesis rather than a means of testing them.

(viii) The method is applicable only to cases of *homogeneous intermixture of effects*.[1] To make it clear, we have to explain what we mean by the Intermixture of Effects.

9. **Intermixture of Effects.**—Causation is a complex phenomenon, in which, as a rule, various agents co-operate to bring about an effect. If the effects of those agents do not intermix, each is distinguishable separately. But when there is an Intermixture of Effects, due to the interference and conjunction of causes, it is, as Mill has pointed out, either (i) Homogeneous, or (ii) Heterogeneous. "It is *homogeneous* when the concurrent causes, whilst more or less modifying, or even counteracting, each other's effects, still exert their full efficacy, each according to its own law—its law as a separate agent.[2]

It is *heterogeneous* or *heteropathic* when 'the agencies which are brought together cease entirely, and a totally different set of phenomena arise: as in the

[1] In cases of '*heteropathic* intermixture of effects,' we must resort to *experiment* alone in order to find out the separate influence of each, and the different effects it will produce in combination with others.

[2] Mill cites the following example to show the mutual interference of homogeneous effects resulting in complete Counteraction:—" A stream running into a reservoir at one end tends to fill it higher and higher, while a drain at the other extremity tends to empty it......Even if the two causes which are in joint action exactly annul one another, still the laws of both are fulfilled: the effect is the same as if the drain had been open for half an hour first, and the stream had flowed in for as long afterwards" (*vide* III. vi. 1.).

experiment of two liquids which, when mixed in certain proportions, instantly become, not a large amount of liquid, but a solid mass'."[1]

A *homogeneous* intermixture of effects is due to a Composition of Causes,[2] the total effect in this case being of the *same kind* as the effects of the single causes acting separately. A *heterogeneous* or *heteropathic* intermixture of effects is, on the other hand, produced by a Combination of Causes, in which case the total effect is of a *different kind* from the single effects, the co-operation of the different causes having undergone mutual modification. When the full consequence of a Law are modified or neutralised by other Laws, it is called a *tendency*. "All laws of causation, in consequence of their liability to be counteracted, require to be stated in words affirmative of *tendencies* only, and not of actual results."[3]

Examples:—

Homogeneous Intermixture:—

(1) Four students, each with a pair of oars, enter a racing boat. Each rows separately in turn, and the boat moves slowly. Now all the four begin to row simultaneously, and the boat moves like a shot.

(2) If two ropes of equal length are fastened to a boat and two men pull it from the opposite shores of a stream and run in the same direction, the boat will move in the middle course, along the diagonal direction of the parallelogram of forces thus formed.

(3) If two forces of equal magnitude are exerted in opposite directions on the same particle, it will not move.

[1] Gibson, *op. cit.*, p. 375.

[2] "I shall give the name of the Composition of Causes to the principle which is exemplified in all cases in which the joint effect of several causes is identical with the sum of their separate effects" (Mill).

[3] *vide* Mill, III. x. 5.

(4) A man's choice of alternatives in the course of his conduct depends on various factors, such as his idea of pleasure, utility, environments, education, instinct, etc.

Heterogeneous or Heteropathic Intermixture :—

(1) A man takes bread, butter, milk and vegetables. This food is assimilated and digested according to certain organic laws, and is converted into flesh and bone.

(2) Common salt is a chemical combination of sodium and chlorine, whose individual properties disappear in the compound.

Conjunction of Causes.

Composition of Causes	Combination of Causes
|	|
Homogeneous	Heterogeneous or Heteropathic

Intermixture of Effects.

10. **Criticism of Mill's Inductive Methods.**—The following are the characteristic defects of the Inductive Methods :—

(i) The state of things presupposed by the Inductive Methods does not actually exist. Our ordinary experience is a continuous flow of happenings, and it is only after its raw materials have been organised into 'antecedents,' 'consequents,' etc., that the Methods are applicable. "They take for granted the very thing which is most difficult to discover, the reduction of phenomena to formula such as are here presented to us" (Whewell).[1] They are therefore of no use in the initial stages of any science, where the *given* is always very complex. "Even if they argue from facts at all, they do *not* argue from *crude* facts, but from a material which has already somehow been cut into definite scientific shapes. They do not, therefore, begin at the

[1] Schiller, *op. cit.*, p. 266. Also cf. A. Sidgwick, *op. cit.*, p. 188 ff.

beginning of Induction, nor do they adequately describe the whole of the inductive process."[1]

(ii) The Methods may be applicable to an abstract universe but not our ordinary world of experience, where their demands can never be complied with. The principles involved in the Methods are, as Mill holds, summed up in the Method of Agreement and the Method of Difference. The former demands two cases which have 'no circumstance in common but one,' but experience does not offer such a situation literally. The latter demands two cases which 'differ in nothing but the presence of one circumstance.' But where are we to find such cases? How could we possibly know "every circumstance" and what meaning could we give to "one" circumstance?' Both these demands are impossible Taking into consideration the remaining Methods also, we find the same remarks applicable to them The Joint Method or the Method of Double Agreement demands instances 'having nothing in common save the absence of a circumstance' This additional demand is alike impossible. The Method of Concomitant Variations speaks of any one phenomenon varying *whenever* another phenomenon varies in a particular manner, and thereby demands a universal connexion between the two even before the Method is applied. Lastly, the Method of Residues admits knowledge arrived at by previous inductions and is really deductive in character.

(iii) The methods aim at establishing laws of causation, but the invariability of sequence is already assumed by the canons.

[1] cf. "The position from which we are thus invited to set out is very far from the beginning of experimental enquiry; the clear-cut instances supposed are possible only in an advanced stage of scientific research."—Laurie, *Mind* (N. S. Vol. ii).

(iv) Mill himself confesses that the Methods are based on false assumptions. " We have regarded *abcde*, the aggregate of the phenomena existing at any moment, as consisting of dissimilar facts *a*, *b*, *c*, *d*, and *e*, for each of which one and only one, cause need be sought......But the supposition does not hold, in either of its parts. In the first place, it is not true that the same phenomenon is always produced by the same cause...And, secondly, the effects of different causes are often not dissimilar, but homogeneous, and marked out by no assignable boundaries from one another." [1]

(v) They are inadequate as methods of Proof and can at best suggest hypotheses.

(vi) " Considered in themselves, and apart from the previous knowledge which gives us the material for them, and from the discretion which leads us to regard their results as tentative and unfinished, the rules for correctly interpreting a piece of observed causation are about as valuable as the rule that in business " All you have to do " is to buy cheap and sell dear. The important question always is, How are we, with the best intentions in the world, to recognise *before the event* the wrong steps we may take in trying to follow these excellent principles? " [2]

(vii) The Methods fail, in spite of their attempted strictness and precision, to avoid *error* in their results. They cannot give us more than merely empirical generalisations, by no means universal principles.

(viii) But a meaning could be given to these Methods, if we substitute " *relevant* facts " for " facts " alone, since, as Dr. Schiller has remarked, they " were not so far wrong in what they meant. Only it is clear that they do not mean what they

[1] Mill, III. x. 1.

[2] Sidgwick, *op. cit.*, p. 188.

say......The reference to relevance will then at once transform the Methods, and render them scientifically workable."[1] While it may have been altogether impossible to find two phenomena "having only *one* circumstance in common" or "differing only in *one* circumstance," we can easily find them having only one *relevant*, (*i.e.*, important for the purpose in view) circumstance in common, or differing only in one *relevant* point. But at the same time, it must be observed that the reference of relevance cannot altogether save the formal validity of the Methods. "To admit relevance is to renounce the ideal of Formal validity" (*ibid*).

11. **Whewell's Criticism of Mill's Methods.**—Whewell questioned the utility of Mill's Methods and the aptness of his illustrative examples. Mill has examined such objections in the last section of Chapter IX of Book III of his *Logic*. We shall only set down the main points of the controversy.

Whewell remarks that Mill's Methods only come into operation after the crude facts of our actual experience have been arranged in neat formulæ, such as are required by the various canons. In any set of complex facts offered to us by Nature, where are we to look for our A, B, C, and *a*, *b*, *c*?

Mill answers that Whewell's criticism of the Methods is similar to that advanced against the Syllogism. It was said that the chief difficulty lay in obtaining the syllogism, and not in judging of its correctness when obtained. But although both objections are true, they are *unimportant*. For, says Mill, if we try to reduce phenomena to formulæ without knowing what they are to be reduced to, we cannot make much progress.

[1]Schiller, *op. cit.* p 268.

Inductive Logic provides us with rules and models to which arguments must conform in order to be conclusive; and the Methods do not profess to be anything more than such rules and models.

Again, Whewell says that no discoveries were ever made by the Inductive Methods. In this objection too, as Mill points out, Whewell was anticipated by the assailants of the Syllogism, who said that no discoveries were ever made by syllogism. But Whewell's objection would apply to all inference from experience. "In saying that no discoveries were made by the Four Methods, he affirms that none were ever made by observation and experiment; for assuredly if any were, it was by processes reducible to one or other of those methods" (Mill).

In reply to Whewell's charge that the Methods take for granted the very thing which is most difficult to discover, Mill says that in the initial stages men do not make use of the Methods in their strict form but of some other form, simpler and looser. For instance, by observing a number of barking dogs, we infer by the Method of Agreement that "Dogs bark." Then, again, I touch the fire and am burnt, I do not touch it, I am not burnt; hence, we infer by the Method of Difference, that "Fire burns."

Both these examples are, however, faulty. The first is an induction by simple enumeration, and in that form none but savages and children would use Agreement. The other example is equally faulty, as it argues *post hoc, ergo propter hoc*. In the two cases of my being and not being burnt by fire, how are we to ascertain that they have "every circumstance in common save one"? These examples rather warn us against the way in which

the Methods are liable to be applied loosely.

Whewell does not deny that the earliest generalisations of science may have been arrived at by some such simple observations, but he is not prepared to accept them as workings of the Methods in their strict form. The fact is that a great deal of work has to be done in the rationalisation of experience and the organisation of material before the Methods could be made applicable.

According to Mill, Logic is principally concerned with Proof as such. The Inductive Methods are "the sole methods of Proof." It is idle to contend that they fail as Method of *discovery*, since discoveries cannot be made by observation and experiment without Deduction.

SUMMARY.

Mill's Inductive Methods :—

I. **Method of Agreement** (**or Single Agreement**).

Statement.—When observation shows that two events accompany one another (either simultaneously or in succession), it is probable that they are causally connected; and the probability increases with the number and variety of the instances.[1]

Formula :

antecedent		consequent.
ABC	————	*a*bc.
ADE	————	*a*de.
∴ A	————	*a* is a causal sequence.

[1] The clumsy canons formulated by Mill are not repeated here. The statements are enunciated after Dr. S. H. Mellone.

The sole invariable antecedent of a phenomenon is probably its cause.

Principle.—Whatever can be eliminated without interfering with a phenomenon is causally connected with it.

Criticism :—

(i) It is a purely Observational Method.

(ii) It can only *suggest* rather than *prove* a causal sequence.

(iii) Its conclusion is only *probable* but not *certain*.

(iv) It is vitiated by the Plurality of Causes.

II. **Method of Difference.**

Statement.—When the addition of an agent is followed by the appearance, or its subtraction by the disappearance, of a certain event, other circumstances remaining the same, that agent is causally connected with the event.

Formula :

ABC — *a*bc.

BC — bc.

∴ A — *a* is a causal sequence.

Principle.—Whatever cannot be eliminated without interfering with the phenomenon is causally connected with that phenomenon.

Criticism :—

(i) It is a mainly experimental Method.

(ii) It *proves* causal sequences by the verification of hypotheses already suggested.

(iii) It requires only *two* instances, a positive and a negative, which are compared.

(iv) It guarantees a *certain* conviction, and is regarded as the fundamental of all Inductive methods.

III. **Method of Double Agreement, or Joint Method of Agreement and Difference.**

Statement.—Whatever is present in numerous observed instances of the presence of a phenomenon, and absent in numerous observed instances of its absence, is probably connected causally with the phenomenon.

Formula :

Positive Instances.	Negative Instances.
ABC — *abc*.	BMN — bmn
ADE — *ade*.	DOP — dop
AFG — *afg*.	FQR — fqr

∴ A—*a* is a causal sequence.

Principle.—Nothing is the cause of a phenomenon in the absence of which it nevertheless occurs, and in the presence of which it nevertheless fails to occur.

Criticism :—

(i) It requires *two sets* of instances, showing respectively the *presence* and the *absence* of the sequence.

(ii) It is a great extension and improvement of the Method of Difference, and one would not use it if the latter could be employed.

(iii) It falls short of the cogency of the Method of Difference, and one would not use it if the latter could be employed.

(iv) It is an essentially observational Method.

(v) Although an improvement on the Method of Agreement, it is not free from the defect of the Plurality of Causes.

IV. **Method of Concomitant Variations.**

Statement.—If two phenomena always vary together, other circumstances remaining the same or varying independently, there is probably a causal connexion between the two phenomena.

Formula :—ABC — *abc*.

A_2 BC — a_2 bc.

A_3 BC — a_3 bc.

∴ A — *a* is a causal sequence.

Principle.—Nothing is the cause of a phenomenon which varies when it is constant, or is constant when it varies, or varies in no proportionate manner with it.

Criticism :—

(i) It is a further extension of Agreement or Difference, or both. It is an improved application of "Agreement" when applied to phenomena which can merely be *observed*; and a more exact application of "Difference" when applied to phenomena which can be controlled by *experiment*.

(ii) It fails to *prove* a causal sequence. The phenomena in question may both be joint-effects of a single cause.

(iii) It is usually employed to determine an exact *quantitative* relation.

(iv) The variation of phenomena holds good only within certain limitations.

(v) It fails to cope with the difficulty of Permanent Causes.

V. **Method of Residues.**

Statement.—Subtract from a phenomenon those elements which are due to known causes, the residue will be the effect of an unknown cause.

Formula :—

$$\left.\begin{array}{l} ABCD - abcd \\ \quad\;\; D - d \\ \quad\;\; C - c \\ \quad\;\; B - b \end{array}\right\} \text{known sequences.}$$

$$\therefore A - a \text{ is a causal sequence.}$$

Principle.—Nothing is the cause of one phenomenon which is known to be the cause of a different phenomenon.

Criticism :—

(i) It rests on previous inductions.

(ii) It is deductive in character.

(iii) It is a *quantitative* method when applied to experimental cases, and *qualitative* when applied to cases of simple observation.

(iv) It is particularly useful in Astronomical and Chemical research.

(v) It is applicable only to cases of *homogeneous intermixture of effects.*

Characteristic Functions :—

The Method of Agreement *suggests* a hypothesis, that of Double Agreement strengthens the suggestion; the Method of Difference *proves* a causal sequence suggested by the other methods; the Method of Concomitant Variations determines the quantitative relation according to which phenomena vary, within certain limits; and the Method of Residues, resting on previous inductions, is most helpful in furthering research in sciences like Astronomy and Chemistry.

The Inductive Methods are essentially principles of Elimination.

Characteristic Defects :—

(i) The Methods demand neat formulae and organisation of material, which do not exist in initial stages. They do not apply to crude facts which we actually encounter in our experience.

(ii) Their demands can hardly if ever be literally fulfilled.

(iii) They propose to establish laws of causation, but themselves assume the invariability of sequence.

(iv) They are based on false assumptions.

(v) They can at best suggest hypotheses but are inadequate as methods of Proof.

(vi) In spite of their strictness, they fail to avoid error

Intermixture of Effects.—It results from the co-operation of agents which bring about a certain effect. Intermixture of Effects may be either :—

(i) Homogeneous, produced by Composition of Causes,

or

(ii) Heterogeneous or Heteropathic, produced by a Combination of Causes.

Mechanical Mixtures and Chemical Compounds illustrate the two kinds respectively.

QUESTIONS AND EXERCISES.

1. Discuss the inter-relation of Mill's Inductive Methods.

2. How are the Inductive Methods viewed as Principles of Elimination?

3. Explain the Method of Agreement, and show how it differs from Simple Enumeration.

4. What are the pre-suppositions and characteristic defects of Mill's Method of Agreement? What is its utility in scientific discovery?

5. Examine Mill's view that Plurality of Causes renders the Method of Agreement uncertain.

6. Why is the Method of Agreement of little value, as compared with the Method of Difference?

7. Explain why the Method of Agreement requires many instances, while the Method of Difference is satisfied with one precise experiment.

8. The Inductive Methods have been called Weapons of Elimination. Discuss the appropriateness of the description.

9. How would Inductive Logic proceed to investigate the influence upon character of any one of the following:—(*a*) climate, (*b*) athletics, (*c*) an artistic profession?

10. What does Mill mean by Cause? How far are his Methods adequate for the discovery of causes in his own sense of the word?

11. Explain precisely the principle of the Method of Difference, contrasting it with that of the Method of Agreement. In what way is it the most superior Method?

12. Distinguish between Positive and Negative Instances. Bring out the importance of the latter in experimental inquiry.

13. Bring out the connexion between the Method of Difference and that of Concomitant Variations.

14. What are the characteristic features of the Joint Method? How is it related to "Agreement"?

15. State fully and illustrate the Method of Concomitant Variations. What are its special advantages? How is it related to the Method of Difference?

16. Analyse and describe in logical terms the method by which any important discovery of recent years was made.

17. Distinguish carefully between the Method of Difference and the Method of Residues.

18. Can the Method of Residues be fairly considered inductive in character?

19. What do you suppose is the main function of the Method of Residues?

20. Criticise Mill's Canons of Induction, and state in what way they may be amended.

21. To what uses are the several Inductive Methods appropriate? Consider the allegation that the Methods are useless, for no discoveries have ever been made by their means.

22 Discuss the main defects of the Inductive Methods.

CHAPTER VII

THE DEDUCTIVE METHOD

1. **Limitations of the Inductive Methods.**—We have seen how the various Inductive Methods help us in establishing generalisations, of varying degrees of certainty, and how helpless they prove when we are confronted with phenomena complex by virtue of a composition of causes having produced intermixture of effects. Such complex phenomena cannot obviously be investigated by the method of simple enumeration, which fails in dealing with situations in which several causes concur in bringing about an effect. Neither can they be investigated by Mill's experimental methods,[1] which, although better instruments than Simple Enumeration, are ineffective, because in most cases the circumstances are so very complex that it seems altogether impossible to create a situation in which we could introduce an agent and watch the result. We seldom, if ever, see two cases occur which differ in all respects but one. Thus, although the Inductive methods have their legitimate function and use, they are unable to take us far enough in the explanation of a phenomenon; and until a phenomenon is

[1] "When the Experimental Methods have done their utmost, there will still remain the task of gathering up the various threads which these methods have singly and separately laid bare, and this can be done only through Deduction or Deductive Synthesis."—Boyce Gibson, *op. cit.* p. 407.

explained it cannot be said to have been *scientifically* investigated, since Science aims at *explanation*. We cannot stretch the Inductive methods too far; they break down as soon as we attempt to apply them to the exceeding complexity of phenomena. These Methods have their limitations, and we must not expect too much out of them.

2. **The Deductive Method.**—If the Inductive Methods fail to yield us any knowledge of the conditions and laws of very complex phenomena, there is another method which comes to our rescue. This method is called by Mill the *Deductive Method*,[1] or more correctly, the *Direct Deductive Method* (or the Physical Method) since it makes use of Deduction in reasoning from the inductions of science to their results in other cases; or, by Jevons, *Combined or Complete Method*, since it combines Induction and Deduction and is consequently a *complex* method.

The Deductive Method consists in the alternate use of induction and deduction, its problem being to find the law of an effect from the laws of the different tendencies of which it is the joint result. We start with the inductions of a science as our premises, and proceed to deduce their results in the case before us and other cases, and then verify such results by reference to facts. Thus, the Method consists of three stages, *viz.* :—

(1) **Direct Induction** : *i.e.*, the inductions already established in a science : their truth must be assumed to begin with.

(2) **Deduction or Ratiocination** : *i.e.*, consequences

[1] "a strengthened Method of Causal Explanation, a Method especially devised to deal with the difficulties arising from Intermixture of Effects"—Gibson, p. 408.

are deducted by ratiocination from the inductions with which we began.

(3) **Verification** : *i.e.*, these consequences are verified by reference to facts of Nature, through Observation and Experiment.

For instance, if we want to explain the law A is B, we start with the hypothesis that B is due to C, then calculate its consequences by deduction, and lastly compare them with P as manifested in experience. If they agree, the hypothesis is accepted, otherwise it is rejected.

The Deductive Method has been usefully employed in Astronomy, Physics, Sociology, Politics and other sciences. The law of gravitation, for instance, is accepted as an induction established in Physics, and then are explained from it deductively the phenomena, such as the movement of the planets round the sun, of bodies on the surface of the earth, etc. Each of the three stages is necessary as an essential part of the method. We cannot start unless we know some laws already established by a science. We accept them as our starting-point, and assuming their truth we argue as to their consequences, and then verify them by observation and experiment. Without the last stage of Verification, our Deductive Method of Science could not be distinguished from the Deductive Method of Geometry, in which if we start with definitions, axioms and postulates (which are accepted as *true*) we must have true consequences, and no further verification is necessary.

Mill seems to value this Method very highly, since he says :—" To the Deductive Method thus characterised in its three constituent parts, Induction, Ratiocination, and Verification, the human mind is indebted for its most conspicuous triumphs in the investigation of nature. To

it we owe all the theories by which vast and complicated phenomena are embraced under a few simple laws, which, considered as the laws of those great phenomena, could never have been detected by their direct study."[1]

3. **Its Application Illustrated.**—We shall now illustrate the application of the Deductive Method by means of examples. For instance, we want to determine the cause of strikes. Now, we know the general law that whenever Capital exploits Labour to a degree which does not allow the workman a living wage, dissatisfaction is bound to result in a strike, which is the only passive weapon in the hands of the oppressed and the weak. We then follow out this principle in its consequences and discuss how far a strike can have valid grounds to stand upon. Lastly, we observe the actual conditions of the strikes we are investigating and see how far they support the induction we started with. Suchlike problems are, however, very complex, and the study of the various conditions in which such phenomena occur as well as the causes that lead to them form a very complicated problem to cause perplexity even to the most experienced statesmen and politicians handling them.

Mill illustrates the application of this method by the following example by which he proves the identity of gravity with the central force of the solar system :—

" First, it is proved from the moon's motions that the earth attracts her with a force varying as the inverse square of the distance. This (though partly dependent on prior deductions) corresponds to the first or purely inductive step, the ascertainment of the law of cause. Secondly, from this law, and from the knowledge previously obtained of the moon's mean distance from the

[1] Mill, Bk. III. xi. 3.

earth, and of the actual amount of her deflection from the tangent, it is ascertained with what rapidity the earth's attraction will cause the moon to fall, if she were no farther off and no more acted upon by extraneous forces than terrestrial bodies are. That is the second step, the ratiocination. Finally, this calculated velocity being compared with the observed velocity with which all heavy bodies fall, by mere gravity, towards the surface of the earth (sixteen feet in the first second, forty-eight in the second, and so forth, in the ratio of the odd numbers, 1, 3, 5, etc.), the two quantities are found to agree." [1]

The rise of water in the pump may also be explained by this method. First, we state the inductions already established in Physics, *viz.*, (*a*) that the atmospheric pressure on a column of water is 14 lb. to the square inch, (*b*) that liquids exert pressure equally in all directions, and (*c*) that pressure in any direction, if not counteracted by an opposite pressure, produces motion. Secondly, we calculate the consequences deduced from these laws. When the position of the pump is raised removing the pressure upon the water within the cylinder, the pressure of the air outside forces this water to rise up. Thirdly, we verify this computation by direct observation. It is found that at the sea-level the atmosphere supports a column of water 32 feet high, and that such a column exerts a pressure of 14 lb. to the square inch. Thus the computed effect corresponds with the phenomenon to be explained.

4. **Sources of Error.**—It may sometimes happen that the consequences as computed by ratiocination may not correspond with the facts observed. This means that error has crept in somewhere. If we are sure of having

[1] Mill, Bk. III. xiv. 4.

correctly observed the facts, it is evident that the error must lie either in the premisses in the first stage, or in the ratiocination in the second stage. We then revise the process of computation, and if the error still persists, we must look upon our premisses with suspicion. Carverth Read[1] mentions the following four ways in which the premisses of a deductive argument are likely to be vitiated :—

(1) We may not have accurately ascertained the laws, or the modes of operation, of the forces present.

(2) The circumstances in which the agents are combined may not have been correctly conceived.

(3) One or more of the agents affecting the result may have been overlooked and omitted from the estimate.

(4) We may have included among the data of our reasonings agents or circumstances that do not exist or do not affect the phenomenon in question.

5. **The Inverse Deductive Method.**—We have seen that the *Direct* Deductive Method starts with laws or inductions, deduces conclusions from them through ratiocination, and then verifies these conclusions by observation with facts. But, as Mill says, " there is a kind of sociological inquiries to which, from their prodigious complication, the method of direct deduction is altogether inapplicable." The forces that operate in the determination of a phenomenon may be too intricate, too complicated or too numerous to be combined in a direct deduction. In such cases we resort to the *Inverse Method*, also called the *Historical Method.*[2] Here we

[1] *vide* Logic. (London, 1898) p. 198.

[2] So called because it is particularly useful in explaining the movements of history and in verifying the results of Politics and Sociology. But its use is not *necessarily* confined to such studies. It is also resorted to in Geology, Biology, etc.

do not start with any generalisations or inductions but with a consideration of the facts of social life and of history, which yields us empirical laws of the phenomenon concerned. We then verify these laws, not by comparison with further facts, but by deduction from the laws of human nature, from the nature of the cause." We must keep clear the distinction between the Direct and the Inverse Method. Whereas in the "method of direct deduction" we compare the results of deduction with observed facts, we here begin by provisionally formulating empirical laws gathered from facts of observation, and then verify these laws by deducing them from "the principles of human nature." In other words, while in the Direct ("Physical") Method, a Deduction is verified by comparison with an Induction, in the Inverse ("Historical") Method, Deduction is called in to verify a previous Induction.

But Carveth Read objects to the mere order of occurrence of the two logical processes of Induction and Deduction as constituting the essential distinction between the two Methods. "For," as he says, "in the first place, in investigations of any complexity both Induction and Deduction recur again and again in whatever order may be most convenient; and in the second place the so-called 'inverse order' is sometimes resorted to in Astronomy and Physics......The essential difference between the Physical and Historical Methods is that, in the former, whether Direct or Inverse, the deductive process, when complete, amounts to exact demonstration; whereas, in the latter, the deductions consist of qualitative reasonings, and the results are indefinite. They establish—(i) *a priori* a merely probable connection between the phenomena according to the empirical law;

(ii) connect this with other historical or social generalisations, by showing that they all alike flow from the nature of races of men under certain social and geographical conditions; and (iii) explain why such empirical laws may fail, according to the differences that prevail among races of men and among the conditions under which they live."[1]

The Inverse Method is more indefinite than the Direct, both in its inductions and deductions, and Carveth Read rightly characterises it as demanding much sagacity and more sincerity, and proposes the precaution to make the empirical law as nearly true as possible.

6. **The Hypothetical Method.**—The Inverse Deductive Method may perhaps be viewed as the most concrete form in which Scientific Method can develop But even this cannot be taken as the final standpoint, since, as Mill tells us, Hypothesis plays a very important part in Scientific Method: "the function of hypotheses is one which must be reckoned absolutely indispensable in science......Without such assumptions, science could never have attained its present state...Nearly everything which is now theory was once hypothesis."[2]

The Hypothetical Method is adopted when we are not aware of the causes operating in a phenomenon but are rather anxious to ascertain them. Although a modification of the Deductive Method, it differs from the latter in one important aspect. In the Deductive Method, the laws which are elaborated through ratiocination are *proved* by experimental methods, while in the Hypothetical Method, they are not proved but *assumed*. Thus the Hypothetical Method is shorter and simpler than the Deductive, and consists of two steps only: (1) Ratiocina-

[1] *op. cit.* p. 200 ff.
op. cit., Bk. III. xiv. 5.

tion, and (2) Verification. Mill says that the legitimacy of this method rests only " on one supposition, namely, if the nature of the case be such that the final step, the verification, shall amount to and fulfil the conditions of a complete induction."

The nature of this Method will become clearer after a perusal of the following Chapter on " Hypothesis." The three methods dealt with here are Methods of Explanation, as distinguished from Induction.

SUMMARY.

Mill's Experimental Methods cannot always be applied: they are helpless, in particular, while dealing with the difficulties arising from Intermixture of Effects.

In such complicated cases, a more strengthened Method of Explanation called the **Deductive Method** is employed.

It consists of three stages: Induction, Ratiocination and Verification. 'Given any complex mechanical phenomenon, the inquirer considers—(i) what laws already ascertained by induction seem likely to apply to it, (ii) computes the effect that will follow from these laws in circumstances similar to the case before him; and (iii) he verifies his conclusion by comparing it with the actual phenomenon.'

This is known as the Direct Method or the Physical Method.

The Inverse Method, or the Historical Method, is used when a phenomenon is too indefinite to be dealt with by Direct Deduction. We start by formulating empirical

laws on observation, and then verify these inductions by means of Deduction.

The Hypothetical Method is a modification of the Deductive Method and consists of two stages only, *viz.* Ratiocination and Verification. The laws developed through ratiocination are not *proved* but *assumed.*

QUESTIONS AND EXERCISES.

1. Set down the limitations of Mill's Experimental Methods.

2. When is the Deductive Method employed? What are its merits?

3. Name the various stages constituting the Deductive Method and show their inter-connexion.

4. Estimate, after Mill, the value of the Deductive Method, and give two examples to show how it is employed.

5. Distinguish between the Direct and the Inverse Methods of Deduction.

6. Describe the Hypothetical Method in its relation with the Deductive Method.

7. Prove, or disprove, inductively, or deductively that—

(a) At certain epochs great men occur in groups.
(b) Revolutions always begin in hunger.
(c) Government is impossible except by the co-operation of the people.
(d) No taxation without representation.
(e) Empires, like Fine Arts, pass through periods of development, culmination and decay.
(f) Freedom means self-determination.

8. Explain the Historical Method of sociological inquiry. Illustrate your answer.

9. Defining *Dew* to be "The spontaneous appearance of moisture on substances exposed in the open air when no rain or visible *wet* is falling," show how the Deductive Method is to be employed to establish the law of causation of the phenomenon from the annexed table of observations:—

Antecedents.	**Consequents.**
(1) Cold metal or stone; Breathing upon.	(1) Deposit of Dew on metal or stone.
(2) Hot weather; Glass of water drawn from deep well; Exposure to external air.	(2) Deposit of Dew on glass.
(3) Inner surface of walls of dwellings; Long continued frost; Thaw; Moisture in air.	(3) Deposit of Dew on the walls.
(4) Night-time; Exposed surface; Thermometric cold; Circulating air; Thermometric heat.	(4) Deposit of Dew on exposed cold surface.

10. How are causes discovered which are less open to observation than the effects?

CHAPTER VIII.

HYPOTHESIS.

1. **Meaning and Function of Hypothesis.**—A Hypothesis is a supposition made in order to explain facts scientifically. It is our attempt at explanation. As scientific investigators we must start with facts, and also end with facts. We start with such known facts as can suggest a provisional supposition, which is developed further into its consequences. The truth of these consequences is again put to test. If they stand verification, the supposition is accepted as a working hypothesis for still further tests. If they do not, it is rejected in favour of another supposition, which too is similarly treated. A provisional hypothesis need not necessarily be abandoned, if it fails in its verification by observation and experiment: it might sometimes have only to be modified. Even a false hypothesis proves of some use in marking the lines of suggestion to be avoided.[1] In fact, each hypothesis, though rejected, tends to furnish us with a better clue to explanation.

Mill defines a Hypothesis as " any supposition which we make (either without actual evidence, or on evidence avowedly insufficient) in order to endeavour to deduce

[1] It is said, for instance, that Kepler conceived an rejected nineteen hypotheses before hitting on a valid one, which would explain the laws of planetory motion.

from it conclusions in accordance with facts which are known to be real."[1]

We are obviously concerned here with a *scientific* hypothesis alone. A hypothesis, in order to be scientific, must lead us towards explanation of facts, and must in itself be verifiable. It must help us in widening the range of our knowledge, rather than in making a clearer statement of what we already know. Hypothesis is mainly a weapon of discovery. Logic can hardly pretend to lay down any rules for making a scientific hypothesis. Much depends on one's insight and natural gift, with which to lay hold on Nature's clues. This is the field in which the genius and originality of a scientist can help him more than anything else. To a scientifically trained mind facts themselves easily suggest the lines of their explanation. Newton, for instance, took a hint from the falling apple, which led him on to the discovery of Gravitation. Hypotheses are suggested by Analogy, Enumerative Induction and the ordinary classifications and generalisations embodied in language.

The chief test of a scientific hypothesis is that it must be verifiable.[2] "Scientific hypotheses," says Joseph, "consist for the most part not in the mere coupling in the mind, as cause and effect, of two insulated phenomena (if the epithet may be allowed) : but in the weaving of a large number of phenomena into a coherent system by means of principles that fit the facts."[3]

2. **Development of Hypothesis.**—A Hypothesis admits of various degrees of probability, and cannot be accepted as valid unless it has passed through several

[1] *op. cit.*, Bk. III. xiv. 4.

[2] "But to be verifiable it must be adequately developable." Gibson, *op. cit.*, p. 328.

Joseph, *op. cit.*, p. 433.

stages of experiment. We begin with a *protisional* hypothesis, a mere supposition suggested by our knowledge of facts under investigation. If this hypothesis *works*, it passes on to a higher stage of probability and becomes a *working* hypothesis. More than one of such hypotheses might sometimes suggest themselves to be equally true. Selection is then to be made, with appeal to facts, as to which can ultimately help us in our explanation. A working hypothesis when established becomes a *legitimate* hypothesis. At this stage it is regarded as a *scientific* hypothesis. "To work well, a hypothesis must be both resourceful and fruitful. To be resourceful, it must be rooted directly (or indirectly through the medium of a general *working idea*) in a reasoned system or science. To be fruitful, it must be capable of continually extending its sphere of verification, and of bringing more and more facts under scientific control."[1] A working hypothesis, in order to establish itself as legitimate, has to be verified by means of the experimental methods, and in particular the Method of Difference. It has also to prove itself as the *only* tenable hypothesis.

A convenient distinction is sometimes made between a hypothesis of *Law* and a hypothesis of *Cause*. The former seeks to give us a sort of quantitative expression of facts, a clear description of their exact character, telling us how they stand in a series of other phenomena and in what manner they happen; while the latter furnishes us with a qualitative expression of facts, by which we obtain an insight into their causes, and are told not simply *how* they happen but *why* they happen as they do. The former is also known as a *descriptive* hypothesis

Gibson, *op. cit.*, p. 328.

It has its own use in so far as it enables us to find out a coherent system to which the facts belong, which in itself may afford us a further clue as to their final explanation. A hypothesis of Cause is also known as an *explanatory* hypothesis.

3. **Conditions of Valid Hypothesis.**—A legitimate hypothesis must fulfil the following conditions :—[1]

(1) It must be suggested by a preliminary survey of facts, and must, therefore, have its object a real cause, a "*vera causa*."[2] Any hypothesis which is not suggested by facts under observation but is an imaginative construction, though helpful to a degree, cannot be accepted as a *scientific* hypothesis. The scientist should scrupulously keep out his own personal equation from the inquiry, and try to be a faithful *photographer* of phenomena, not projecting his own preconceived notions into them. A spirit of impartiality in all observations and verifications is a *sine quá non* of the success which may attend in the working of a hypothesis. Claude Bernard rightly observed : "On entering the laboratory leave your imagination with your overcoat in the vestibule, but take it with you again on your departure."[3] This is, indeed, a very sound advice to all students of science.

(2) It must be verifiable, *i.e.*, it must be capable of proof or disproof. We must not, for instance, assume the cause of a phenomenon that cannot be verified in nature, because of its supernatural or imaginary character. It must be capable of becoming an object of our experience, and definite enough to be proved or disproved in our

[1] Coffey, *op cit*, vol. II., pp. 148 ff. Joyce, *op cit* p 359

[2] A *vera causa* is a real cause, a cause independently known to exist.

[3] Claude Bernard, *Introduction à l'étude de la médecine expérimentale*, p. 44, quoted also by Coffey, *op. cit.* vol. II. p. 149.

experimental inquiry relating to facts. Carveth Read points out the same truth thus: "If a new agent be proposed, it is desirable that we should be able directly to observe it, or at least to obtain some evidence of its existence of a different kind from the very facts which it has been invented to explain.[1]

Then, again, a hypothesis cannot be accepted as scientific unless it can *adequately* explain the facts in question, *i.e.*, can account for *all* the phenomena which it attempts to explain. A *partial* explanation is no better than an attempt to explain away facts, but the truth is that a *fact* can never be 'explained away.'

Again, in order that a scientific hypothesis be verifiable, it must be *self-consistent*, and must not conflict with other pre-established truths. If it is true, it must necessarily be self-consistent, since truth knows of no contradiction. Thus, a scientific hypothesis must be free from any internal contradiction. At the same time, it must not clash with other extablished laws, as otherwise it will have no place in the system to which all truths belong. We must, however, be on our guard as to where there is any *real* contradiction. Sometimes it so happens that only a superficial conflict with certain truths is revealed, which is capable of elimination by a mere restatement or re-interpretation of those truths or laws from different stand-points.

(3) It must stand as the only hypothesis, excluding all other hypotheses, to explain a fact or a group of facts. Until this requirement is also fulfilled, we cannot be said to have formed a legitimate hypothesis. There might be proposed a number of rival theories, but a further test must eliminate all and prove one alone to be capable of

[1] Carveth Read, *op. cit.*, p. 270.

adequately explaining all the phenomena which it is proposed to explain.[1]

(4) Exceptio probat regulam.—In testing the truth of a legitimate hypothesis *exceptions* are of great value. They do not by themselves *prove* the rule but *test* it. When, after the application of a working hypothesis, a general law is enunciated as based on a group of observed facts, objections might be urged against the validity of such hypothesis in the shape of pointing out cases not covered by the hypothesis, or those that are apparently exceptions to it. But " every objection is shown to imply some inattention to the conditions of the hypothesis, and in each case it may be said, *exceptio probat regulam*—the exception *tests* the rule. That is to say it appears on examination (1) that the alleged exception is not really one, and (2) that it stands in such relation to the rule as to confirm it.[2] Strictly speaking, there is no room for exceptions in scientific explanation. Either the exceptions prove to be superficial, and thus only confirm the truth of the rule, or they are discovered to belong to another system, wherein they cease to be exceptions. A scientific law must be applicable *universally* and have no exception, in the sense of a contradiction.

5. **Crucial Instance.**—We have observed that a scientific hypothesis must be the *only* hypothesis to account for a phenomenon. Now, when rival hypotheses are forthcoming, we have to decide as to which of them would prove legitimate. This is done by means of a Crucial Instance, one that could only be explained on only *one* of such hypotheses, and which, therefore, decides the point at issue. A crucial instance serves as a sign-post

[1] On the subject of the sources of Hypotheses, *vide supra* under Analogy and Enumerative Induction.

[2] Carveth Read, *op. cit.*, p. 274.

to point out the direction of Truth.' If it is arrived at by experiment, it is called a Crucial Experiment.' The function of a crucial instance is to enable us to finally reject one hypothesis and accept *one* and *only one* as valid ' One single circumstance, which admits of one explanation *only*, is more decisive than a hundred others which agree in all points with one's own hypothesis, but are equally well explained on an opposite hypothesis.''[1]

The term was first employed by Bacon to denote an instance which absolutely excludes one alternative, thus establishing the other. The metaphor is taken from the cross-posts, which stand at the meeting-point of two roads, pointing the way to be taken.

When a hypothesis has been established by a crucial instance, what reason is there to suppose that no other alternative will yet clash with it? Can we ever be certain of having excluded *all possible* alternatives? That we can never be, in the strictest sense.[2] But if we be fortunate enough to find crucial instances whenever there is any clash of alternatives, we may rest assured that we have arrived at that degree of probability, which is as good as certainty, so long as our hypothesis is found to be the only possible one. In this part of our inquiry logic cannot lay down any rules, except the general directions for adequate observation and experiment. The fact is that Science is not a completed circle of facts but is daily growing in its scope and contents, so that all our hypotheses are ultimately provisional, and they are legitimate only so long as they work. The Ptolemaic and Copernican hypotheses are an instance in point.

[1] Uberweg, *Logic* (Eng. Trans.), p. 513.

[2] cf. " It is always possible that some future investigator, going over the same ground, will be able to show that the information given by the experiment " (crucial) " was ambiguous." A. Sidgwick, *op. cit.*, p. 142.

6. **"Hypothesis non fingo."**—This was the expression used by Newton in protest against hypotheses and means "I do not imagine hypotheses." This condemnation can rightly be urged against all hypotheses that are arrived at very hastily, and are neither adequate nor definite. They usually suggest themselves to minds not trained in scientific thinking. When there is no analogy to guide us in the choice of hypotheses, or when we do not take the trouble of finding such an analogy, we often frame illegitimate hypotheses. Such might with reason be condemned by using the expression "hypothesis non fingo," but that is no reason why all hypotheses as such should be condemned. There is no progress in science without the aid of hypotheses. We have to grope in the dark for a long time before we hit at the thing we require. Carveth Read rightly emphasises the fact that "Hypotheses are essential aids to discovery: speaking generally, deliberate investigation depends wholly upon the use of them." Even Newton himself worked with the aid of hypotheses in discovering the Law of Gravitation. But, of course, unscientific and gratuitous[2] hypotheses should always be rejected.

7. **Hypothesis**: **Theory**: **Fact.**—Hypothesis is usually distinguished from Theory by saying that while the former is always more or less tentative, the latter is a higher stage of explanation, no longer open to question. That is to say, a hypothesis well established becomes a

[1] Carveth Read, *op. cit.*, p. 280.

[2] A *gratuitous hypothesis* is "the assumption of an unknown cause, when the phenomenon is capable of being explained by the operation of known causes, or the introduction of an extraneous (though it may be known) cause, when the phenomenon is capable of being accounted for by the causes already known to be in operation" (Fowler).

Theory. We speak of the *theory* of gravitation, not of the *hypotheses* of gravitation, although ultimately all *theories* are *hypotheses*. Again, those who do not accept a certain theory generally prefer to speak of it as a *hypothesis* rather than a *theory*. This applies for instance to Evolution, Electron, Creation, etc.

A theory whose truth is established is accepted as a *fact*. The term *fact* is generally confined to the objects of our experience, objects whose reality can be grasped by our senses or by the mind. Some people narrow down its meaning to objects that can be perceived by the senses alone. but this is more or less arbitrary.

SUMMARY.

Hypothesis is a supposition by which we attempt an explanation of facts. A scientific hypothesis must be *verifiable*.

We may speak of *stages* in the development of a hypothesis. We start with a Provisional hypothesis, which becomes a Working hypothesis, if it works. If it is established by the test of verification, it is accepted as Legitimate or Scientific hypothesis.

A hypothesis of Law is only a *descriptive* hypothesis, while that of Cause is an *explanatory* hypothesis.

A scientific hypothesis (1) must be suggested by a preliminary survey of facts, (2) must be verifiable, *i.e.*, capable of proof or disproof, and (3) must be the *only* hypothesis, excluding all others.

A Crucial Experiment is one that suggests a Crucial Instance, like a finger-post at cross-roads, pointing the way. A Crucial Instance is an instance which absolutely

excludes one alternative, thereby establishing the other, when there are rival hypotheses suggested.

Newton's dictum "Hypothesis non fingo" cannot be accepted as a condemnation of hypotheses as such, since scientific hypotheses are essential means to discovery. It could only apply to *bad* hypotheses and hasty generalisations.

A *hypothesis*, when well-established, becomes a *theory*; and a theory when accepted is treated as a *fact*.

QUESTIONS AND EXERCISES

1. What is the function of hypothesis? Is every supposition in science a hypothesis?

2. Explain the meaning of hypothesis as a conscious process of scientific investigation. Show that a rejected hypothesis need not necessarily prove fruitless.

3. Illustrate the use of hypothesis in scientific explanation.

4. State the conditions to which a legitimate hypothesis must conform.

5. Distinguish between a *working* and an *established* hypothesis. Give easy examples.

6. Describe the various kinds of hypothesis distinguished by logicians, and compare them with one another.

7. Explain and criticise:—(a) "Men are now cured of their passion for Hypotheses," (b) "Hypothesis non fingo."

8. Explain the role of analogy in suggesting and verifying hypotheses.

9. Taking the "evolution," or any other proposed hypothesis, how should one proceed (a) to show whether it satisfies the conditions of a legitimate hypothesis sufficiently to entitle it to investigation, and (b) to test it with a view to its acceptance or rejection as a truth of science?

CHAPTER IX.

EXPLANATION.

1. **Nature of Explanation.**—Explanation marks the goal of scientific inquiry. Literally, the word means the making plain or clear, so that there shall be nothing uneven or obscure to interrupt our view. Explanation presupposes something to be explained, *i.e.*, a state of prior obscurity or perplexity, the degree of which depends on our educational level and the state of our mental development and partly on the progress of knowledge as a whole. For instance, the phenomena of Thunder-storm, Volcanic Eruptions, Earthquakes, etc., were very much more obscure during the beginning of the last century than they are now, as the world's knowledge has considerably increased since then. They might even to-day be obscurities to those minds that are not conversant with the general principles of science, especially of Physics. Explanation seeks to answer the " why " so deeply rooted in the human mind. Even children are always curious to know *why* a certain phenomenon is as it is. They ask so many questions about things around them, and that is Nature's way of educating them to begin with.

A fact is *explained* when we point out its cause. This may be done either by showing it to follow from the

application of a law, or by pointing out its relations to other facts constituting the same universe. A "law" again suggests a "why" of its own, demanding further explanation, and it is said to be explained when we show its connexion with certain other already known laws, from which it can be deduced. This explanation of laws takes place in one of the three ways, of which we shall speak below.

2. **Popular and Scientific Explanation.**—We may first distinguish the popular notion of Explanation from the scientific view, since we are concerned with the latter only. The principle is the same in both, *viz.*, generalisation.[1] In popular explanation it is considered sufficient if particular facts to be explained can be related to others known previously. More often, we confine our attention to the explanation of *facts* rather than of *laws*. Bain observes: "There is a special and everyday form of explanation that consists in assigning the agency in a particular occurrence; as when we ask—what stops the way? Who wrote Junius? Who discovered gunpowder? These questions belong to our practical wants and urgencies, but the answer does not involve the process of scientific explanation. If, however, we proceed from the 'who' or 'what' to the '*why*':—why does A's carriage stop the way? Why did the author of Junius write so bitterly?—there is an opening for the higher scientific process."[2] In the popular view, therefore, facts are explained when they cease to remain *isolated* but are brought into relation with others, already known, or, at any rate, better known.

[1] Generalisation is the discovery of resemblance amid differences, the detection of the universal in the particular. See below, sect. 5.

[2] Bain, *Logic* (Induction), p. 116.

In *scientific* explanation, our treatment of relating particular facts to more general or better known facts or laws is as full and precise as possible, and the laws under which facts or less general laws are placed are supposed to be the widest possible, preferably the laws of nature.

The popular mind is usually satisfied when we substitute one mystery for another to be explained. For scientific purposes, however, we must trace that mystery as far back as we possibly can. On this subject we had better quote a well-known paragraph from Mill. He writes :—

"The word explanation is here used in its philosophical sense. What is called explaining one law of nature by another is but substituting one mystery for another; and does nothing to render the general course of nature other than mysterious. We can no more assign a *why* for the more extensive laws than for the partial ones. The explanation may substitute a mystery which has became familiar, and has grown to *seem* not mysterious, for one which is still strange. And this is the meaning of explanation in common parlance. But the process with which we are concerned often does the very contrary; it resolves a phenomenon with which we are familiar into one of which we previously knew little or nothing; as when the common fact of the fall of heavy bodies was resolved into the tendency of all particles of matter towards one other. It must be kept constantly in view, therefore, that in science, those who speak of explaining any phenomenon mean (or should mean) pointing out not some more familiar, but merely some more general phenomenon, of which it is a partial exemplification; or some laws of causation which produce it by their joint or successive action, and from which,

therefore, its conditions may be determined deductively. Every such operation brings us a step nearer towards answering the question which was started in a previous chapter as comprehending the whole problem of the investigation of nature, *viz.*, what are the fewest assumptions, which being granted, the order of nature as it exists would be the result? What are the fewest general propositions from which all the uniformities existing in nature could be deduced?"[1]

Popular explanation does not give us the 'why' or the 'wherefore' of a fact. That is only possible in scientific explanation, which refers to principles and laws, *priora in se*, through not more familiar to us. There is, of course, a limit to such references. The ultimate "why" of things cannot be answered by science. It remains a mystery to furnish materials for the philosopher's cogitations.

3. **Forms of Scientific Explanation.**—There are three modes of scientific explanation, which are appropriately named Analysis, Concatenation, and Subsumption.[2]

(i) *Analysis* : the passing from fact to law. The analysis of a phenomenon into the separate laws of its causes constitutes the first mode of scientific explanation. Thus, for instance, to explain why thunder follows lightening we have to analyse it into (1) the discharge of electricity in the air (2) distance of the observer from the event, and (3) the law that light travels faster than sound. Similarly, in explaining why iron floats in mercury we have

[1] Mill, *op. cit.*, III. xii. 6.

[2] vide Carveth Read, *Logic*, 1914, pp. 302-305.

to resolve it into (1) the laws of floating bodies (2) the law of density (3) the law of specific gravity.

(ii) *Concatenation* : "the discovery of steps of causation between a cause and its remote effects; the interpolation and concatenation of causes." This is the second mode. Here we detect an intermediate link of causation between what was first supposed to be the cause and what was supposed to be its effect. We show that such supposed cause was really the remote cause, the cause of the cause. For instance, we say in India "good monsoon, good harvest." Good harvest is the result of several factors which are mainly brought about in their turn by a good monsoon.

(iii) *Subsumption* : the placing of several laws under one more general expression. This is the third mode of scientific explanation. For instance, the laws of the expansion of solids liquids and gases, by heat, are resolved into the general law of the expansion of bodies by heat.

In all these forms of explanation, facts and laws are harmonised : a less general law is referred to a more general law. Partial laws are unified under more universal laws, and this goes on till we discover *the most general laws.*

4. **Limits of Explanation.**—If the line of scientific explanation moves on towards the subsumption of partial laws under more general ones, the question is where it is going to end. Are there any limits to this process? This question is asked by Mill, after he has distinguished

derivative laws (those that can be resolved into more general ones) and *ultimate laws* (those that cannot be thus resolved) and has observed : " We are not sure that any of the uniformities with which we are acquainted are ultimate laws; but we know that there must be ultimate laws; and that every resolution of a derivative law into more general laws, brings us nearer to them."[1] The question is, shall we be satisfied if we discover those ultimate laws, or must they be further resolved into some one universal law?

We explain the particular with reference to the universal. But when we arrive at certain final uniformities of nature, the widest generalisations of induction, are we to stop there and treat them as self-explanatory or try to explain them in turn by reference to a still wider uniformity, if any? The only evidence of their truth, it is urged, lies in the facts of experience, since they do not strike us as self-evident truths in the sense in which for instance, the axioms of geometry are. We cannot rationally account for the organisation of our experience without such ultimate uniformities. Hence these laws are ultimately nothing more than *postulates*. They possess for us a kind of hypothetical truth, since without their assumption we cannot explain our experience.[2] Scientific explanation is powerless to go beyond these ultimate laws. Philosophy alone does away with all such " hypothetical " truths.

The phenomena of nature are only particular *cases* of the Laws of Nature. For instance, it is erroneous to

[1] Mill, *op. cit.*, III. xiv. 1.

[2] cf. " The belief that there are Laws of Nature, *in the plural*, is the scientific assumption *par excellence*, and their discovery is the unceasing concern of science." Schiller, *op. cit.*, p. 313.

speak of the laws of falling bodies as having been due to the law of gravitation. The former less general laws are not the *effects* but only *cases* of the more general law of gravitation. They pre-suppose a number of permanent causes, which, as Mill says, " have subsisted ever since the human race has been in existence, and for an indefinite and probably an enormous length of time previous. The sun, the earth, and planets, with their various constituents, air, water, and other distinguishable substances, whether simple or compound, of which nature is made up, are such Permanent Causes...But we can give no account of the origin of the Permanent Causes themselves. Why these particular natural agents existed originally and no others, or why they are commingled in such and such proportions, and distributed in such and such a manner throughout space, is a question we cannot answer."[1] Neither do we expect Mill or the methods of science to answer this question, which, however, is the most fundamental question of Metaphysics.

Scientific explanation swings between the two extremes of the most particular and the most general. The following mark the limits of scientific explanation :—

(1) Fundamental states of consciousness are their own explanation and cannot be explained further. For instance, our feelings of colour, smell, etc., are ultimate and unique : they cannot be resolved into any simpler states, hence they cannot be explained.

(2) Certain ultimate principles cannot be explained, *e.g.*, the atom, matter, inertia, gravity, energy, etc.

(3) Individual peculiarities of particular objects too cannot be explained.

[1] Mill, *op. cit.*, III. v. 8.

5. **Generalisation.**—In our attempt to understand the meaning of any fact or phenomenon we always proceed by viewing it in relation to the whole or the system to which it belongs, since our experiential world is a world of relations. There are no isolated facts at all. They may appear so, as long as we do not understand them. All our explanation involves generalisation, which means, in other words, that it is an attempt to bring the particular in relation to the more general. When we refer a fact to a law, *i.e.*, when we connect it with similar other facts, all forming instances of one and the same law, we are already generalising.[1] Such law may further be explained by a wider law, and all such process of thought which studies the particular in the light of the universal is called generalisation. In this process we have to compare facts with others previously known, find out their similarities and dissimilarities by abstraction, and thus proceed to the subsumption of facts under concepts. But this process is open to two special risks, which are mentioned by Venn :—

(i) The difficulty of clearly detecting the common quality in a number of given instances of a certain class, and

(ii) Even if the quality is detected, the instances in which it is recognised may never have been classed together.[2]

[1] So far it is only an *empirical* generalisation, needing further explanation. It is more descriptive than explanatory, but all the same a necessary stage towards the final establishment of truth, *i.e.*, explanation. An empirical law is only a law of sequence and co-existence and must not be relied on beyond the range of the facts considered by it. It must always be gained by direct observation. It points to the need of a further systematisation.

[2] Venn, *The Principles of Empirical or Inductive Logic*, p. 347, cf. Gibson, *op. cit.*, p. 340.

6. **Classification.**—The second difficulty mentioned by Venn in the process of generalisation leads us to consider the meaning of Scientific Classification. When the quality common to a number of instances is detected, or is obvious by itself, the function of Classification is to bring all such instances together under one class-concept. Classification is to be distinguished from Definition in so far as the former is concerned with generalising concepts under concepts and the latter with generalising facts under concepts. Thus, we see that Definition and Classification mark the road towards Explanation. Classification cannot, however, go beyond arranging facts for us in separate bundles, as it were, labelling them with class-names on the basis of common affinity. By pointing out similarities and differences it helps in suggesting the directions to be followed for arriving at scientific explanation. "In classifying, we describe what is; in explaining, what must be, and why it must be."[1]

7. **Natural and Artificial Classification.**—Can there be *natural* classification? Are there *classes* in Nature? The ancient view of the immutability of species and the rigidity of classes is now abandoned. It is believed that nature is one vast organism, in which all facts or phenomena are interconnected, and the various species constantly grow into higher and higher types, or degenerate into lower forms; in fact, there are no distinct watertight compartments in nature. This is very true, indeed; but it should by no means make the process of classification and definition impossible. It is enough if we keep this truth in mind while treating classes and

[1] Hobhouse, *Theory of Knowledge*, p. 473.

concepts for purposes of scientific explanation.[1] We may, therefore, lay down the following conditions which a Natural Classification must fulfil :—[2]

(i) It should enable us to make the greatest number of general assertions about the class.

(ii) It should enable us to infer of any other member of a class a great part of what we knew about any one.

(iii) It should point out the greatest similarity in the members of a group, and the least affinity to members of other groups.

A classification is called *Artificial*, when it is based on a single attribute or extremely limited number of attributes. Such classification is usually resorted to for purpose of ready references or other facilities. For instance, books in a library are arranged according to size or subject or language for easy access. Any one common attribute may be selected for artificial classification ; the

[1] cf. the following paragraph from Cairnes, *Logical Method of Political Economy*, p. 139, quoted by Mellone in his *Introductory Text-Book of Logic*, 1905, p. 142 :—"To admit of degrees is the character of all natural facts ; there are no hard lines in nature. Between the animal and the vegetable kingdoms, for example, where is the line to be drawn? I reply that I do not believe that there is any absolute distinction whatever. External objects and events shade off into one another by imperceptible differences ; It is, therefore, no valid objection to a classification, nor, consequently, to the definition founded upon it, that instances may be found which fall, or seem to fall, *on* our lines of demarcation. This is inevitable in the nature of things. But, this notwithstanding, the classification, and therefore the definition, is a good one if in those instances which do *not* fall on the line, the distinctions marked by the definition are such as it is important to mark, such that the recognition of them will help the inquirer forward towards the desiderated goal."

[2] *vide* Mellone, *ibid*, See also Joyce, *op. cit.*, p. 391.

selection depends on the purpose in view. Different individuals guided by their different interests, may classify the same objects into different groups. For instance, a group of pictures will be classified by an artist according to the various schools of form and colour, by a historian according to the time of their production, by a dealer according to their value, and so on.

In science we sometimes group together classes in a series, as will help us in the discovery of their affinities For instance, we study natural history as Botany, Zoology, Minerology, etc. This is called *Classification by series*. The object of such classification is, in the words of Mill, to "arrange those kinds in a series, according to the degree in which they exhibit it, beginning with those that exhibit most of it, and terminating with those that exhibit least."[1]

8. **Scientific Method.**—Scientific Method is a systematic manner of carrying on the search for truth.' By long training and experience, students of scientific investigation are able to mark out lines on which we should proceed with a view to the discovery of explanation of facts. There is, of course, method in every art and organisation. Its application gives us skill and power. But we are now concerned only with strictly scientific method. There are two fundamental ways in which our mind works in its endeavour after the attainment of scientific knowledge : *Analysis* and *Synthesis*. When we start with particular facts and events, study them in their mutual relations, classify them into groups, generalise facts into laws, etc., we are following the Analytic method. On the other hand, when we start with universal laws and trace them out to their consequences,

[1]Mill, *op. cit.*, IV. viii. 1.

pass from the cause to the effect, from the law to the particular facts, from essence to property, we follow the Synthetic method. Both these methods are most commonly used in science and philosophy. Science, however, has a wider scope for the application of the analytic method, and all our modern discoveries are mainly arrived at by this method. In Mathematics, however, we start with general principles, and proceed synthetically. The two methods may best be regarded as mutually supplementing each other. When we start with facts and proceed to universal principles, it is always suggested that such principles may again be verified and demonstrated by reference to a wider range of facts. This, therefore, combines the analytical and the synthetic methods.

Scientific Method not only familiarises us with the two systems of Analysis and Synthesis, but is of a further help to us in pointing out a few fundamental rules to guide us in the disposition and arrangement of our materials and argument. Obviously no hard and fast rules can be of much utility, since there are endless ways in which things may arrange themselves, and common sense may be our best guide all through. But, none the less, scientific training is of material help to common sense. The Rules of Method, therefore, perform a useful function.

Newton lays down the following "rules of philosophising" in his *Principia* :—

RULE I. "No more causes of natural things are to be admitted than such as are both true and sufficient to explain the phenomena of those things."

RULE II. "And therefore natural effects of the same kind are to be referred as far as possible to the same causes."

RULE III. "Those qualities of bodies that can neither be increased nor diminished in intensity, and which are found to belong to all bodies within the reach of our experiments, are to be regarded as belonging to all bodies whatever."

RULE IV. "In experimental philosophy, propositions collected by Induction from phenomena are to be regarded as exactly true or as very nearly true, notwithstanding any contrary hypotheses, until other phenomena occur, by which they are made more accurate or are rendered subject to exceptions."

This is a statement of what Newton considered to be the true method to be followed in Natural Philosophy. A more general statement of the Rules of Method, which could be applied to *all* Philosophy is given by Descartes in his *Discourse on Method* :—

I. Never to accept anything as true which we do not known to be such.

II. To divide each of our difficulties into as many parts as possible (analysis.)

III. To proceed from the simple to the complex.

IV. To make our enumerations complete.

These are not meant to be concrete rules, but only general directions for philosophical thinking, which, according to Descartes, must always be *clear and distinct* on order to be true.[1]

9. **Nomenclature and Terminology.**—It is easy enough to think, through images, of particular facts or individuals. But when we are thinking of general notions, laws and principles, we require something more

[1] Aldric's *Logic* gives the following Rules :—(1) Nothing should be wanting or redundant (2) The separate parts should agree with each other (3) Nothing should be treated, save what is suitable to the subject or purpose (4) The separate parts should be connected by suitable transitions.

than images. We require symbols to convey our ideas about things or their properties. Clearness of our thought rests a great deal on clearless of language. Precise expression is very useful and necessary aid to precise thought. Much harm has, for instance, been done in Philosophy by a confusion or misuse of expression.

What we, therefore, require is :—

1. **A Nomenclature,** or " system of names of all classes of objects, adapted to the use of each science."[1] These names must not be too fluid ; they must easily and efficiently express the definite class of objects of which they are designed to be a symbol. Some sciences, like Chemistry, Music, Mathematics, etc., have their own special nomenclature.

2. **A Terminology,** " to describe and define the things that constitute the classes designated by the nomenclature, and to describe and explain their action." (*ibid*). This presupposes that there should be a distinct name for every distinct part of an object ; a name for every quality of an object, and for its degrees and modes; and a name for every separate process in nature. A careful use of terminology goes a long way in contributing to the clearness of our thought and expression.

SUMMARY.

A fact is *explained* when we place it under a more general law, and a law is explained by being subsumed under a still more extensive uniformity. Explanation answers the ' *why* ' of a thing by tracing its cause. It is the goal of all scientific investigation.

[1] Carveth Read, *op. cit.*, pp. 348-351.

Three modes of scientific explanation :—

(i) *Analysis* : passing from fact to law.

(ii) *Concatenation* : the discovery of the steps of causation between a cause and its remote effects.

(iii) *Subsumption* : the placing of several laws under one more general expression.

In our explanation, we cannot go beyond the Ultimate Laws of Nature, whose truth we have to accept hypothetically in reference to the facts of experience. The phenomena of nature are only particular *cases* of the Laws of Nature, not their *effects*.

The ultimate principles of nature, the fundamental states of our consciousness, and the individual peculiarities of particular objects, cannot be explained.

Generalisation is the process of viewing a fact in relation to the whole or the system to which it belongs. Truths are established through empirical generalisations. Generalisation involves Abstraction and Comparison.

Classification brings together a number of instances under one group on the basis of one or common attributes. *Artificial* classification is generally based on the affinity as to a single attribute (selected for a definite purpose), while *Natural* classification is based on the greatest number of similar attributes in the members of a group. We must, however, bear in mind that there are no distinct and immutable species in Nature.

Scientific Method is a systematic manner of carrying on the search for truth. Its two main aspects are :— *Analysis*, proceeding from particular facts to their laws, from the concrete to the abstract, from the particular to the more general, from properties to their essence, from effect to cause; *Synthesis*, proceeding from laws to their application, from the abstract to the concrete, from the

universal to the particular, from essence to properties, from cause to effect.

Descartes' four Rules of Method :—

1. Never accept anything as true unless known to be such.

2. Divide each difficulty into many parts.

3. Proceed from the simple to the complex.

4. Make enumerations complete.

For clear thinking we also require (i) a Nomenclature, or a system of names, and (ii) a Terminology to define the exact meanings of the things forming classes designated by the nomenclature.

QUESTIONS AND EXERCISES.

1. What is meant by "Explanation" in Science? Give also the popular meaning.

2. What is the object of Explanation? Describe and illustrate its principal forms.

3. ' The object of science is *explanation.*"

" Science never *explains*: she only reduces complex events to simple ones of the same kind, as when she deals with certain phenomena of magnetism by supposing every ultimate unit of the substance to act as if it were a magnet."

Consider these statements.

4. Indicate the meaning of the term 'law' as employed in natural science. Distinguish between empirical laws, laws of nature, and ultimate laws.

" A truly universal law is not a demonstrable truth." Discuss.

5. Discuss the three modes of scientific explanation, and set down the limits of explanation.

6. What is the function of Generalisation in Induction?

7. Explain the nature and use of Classification, the means to, and tests of, its successful performance.

8. Discuss the value of Natural Classification as a scientific method.

9. Distinguish between the aims of Classification and Logical Division.

10. What is meant by Scientific Method? Distinguish between Analysis and Synthesis as scientific methods.

11. Examine the methodological relations between Definition, Classification and Nomenclature.

CHAPTER X.

FALLACIES.

1. **Meaning of Fallacy.**—The term "Fallacy" has been used in a wider as well as a narrower sense. In its widest sense it implies 'any erroneous judgment or belief,' and as error conforms to no law and its possibilities are countless, any systematic treatment of fallacies in this sense is obviously impossible.[1] More strictly, however, the term is applied to 'any error due to the violation of a logical principle.' All errors cannot, of course, be called fallacies, but only such as possess a semblance of validity, while violating some logical principle.

Fallacy must be distinguished from Paralogism, Sophism and Paradox. Kant distinguished Paralogism and Sophism on a purely psychological basis, and has been followed by several others after him.[2] He defined Paralogism as a fallacy deceiving the person who employs it; and Sophism, which deceives the person to whom it is addressed. Carveth Read says: "A Fallacy is any failure to fulfil the conditions of proof.

[1] cf. the author's *Elements of Deductive Logic*, Calcutta, 1918, pp. 347 ff.

But a distinction based on purely psychological grounds has no value in Traditional Logic.

If we neglect or mistake the conditions of proof unintentionally, whether in our private meditations or in addressing others, it is a Paralogism; but if we endeavour to pass off upon others evidence or argument which we know or suspect to be unsound, it is a Sophism."[1] De Morgan takes Paralogism "to specify an offence against the formal rules of inference," but in this sense it is apt to be easily confounded with Fallacy. The term "Sophism" has been used, since Aristotle, to signify dialectic traps laid intentionally to deceive the opponent.

Fallacy may also be distinguished from Paradox, which, as De Morgan observes, "is properly something which is contrary to general opinion; but it is frequently used to signify something self-contradictory. The more precise writers of our day use the word paradox for an opinion so very singular and improbable, that the holder of it is chargeable with an undue bias in favour of singularity or improbability for its own sake."[2]

2. **Classification of Fallacies.**—We have mentioned elsewhere some of the ways in which Fallacies have been classified, and have discussed them very briefly after Aristotle's scheme. We give below the outlines of some of the principal schemes of their classification.

Aristotle divides fallacies into two groups, *viz.*, fallacies "*in dictione*," *i.e.*, those due to the ambiguous use of language; and fallacies "*extra dictionem*, *i.e.*, those which spring from a source other than the ambiguous use of language, and which can only be detected by an examination of the matter dealt with. The first group comprises six kinds of fallacies, and the second comprises seven; thus—

[1] *op. cit.*, (1914 ed.), p. 385.

[2] De Morgan, *Formal Logic*, p. 338, also quoted by Welton, *Manual of Logic*, vol. II. p. 229.

A. Sophismata in *dictione* :—

(1) *Equivocatio*: Equivocation: due to ambiguity in a single term.

(2) *Amphibolia*: Amphiboly or Amphibology: due to ambiguity in the construction of a sentence.

(3) *Compositio*: Composition: due to taking together what ought to be kept separate.

(4) *Divisio*: Division: due to separating what ought to be kept together.

(5) *Accentus*: Accent: due to ambiguity of accent or emphasis

(6) *Figura Dictionis*: Figure of Speech: due to ambiguity from the metaphorical use of words.

B. Sophismata *extra dictionem* :—

(1) *Accidens*: Accident: due to equating subject with attribute.

(2) *a dicto secundum quid ad dictum simpliciter*: due to confusing a statement made with some limitation with one made absolutely.

(3) *Ignoratio elenchi*: Refuting the wrong point, or mistaking the point in debate.

(4) *Petitio principii*: Begging the question: assuming in some form or other the proposition to be proved.

(5) *Non causa pro causa*: Deducing a conclusion from an irrelevant premiss.

(6) *Consequens*: Consequent: assuming that a hypothetical proposition is always and necessarily reciprocal.

(7) *Plures interrogationes*: Many questions: putting a question in such a form that a single answer involves more than one admission.

Whately gives us the following scheme :—

A. *Logical* Fallacies, "where the conclusion does not follow from the premisses," including :—

(1) *Purely Logical*, whose mere *form* exhibits their fallaciousness,

(2) *Semi-logical, viz.*, "all the cases of ambiguous middle term except its non-distribution."

B. *Material* or Non-logical Fallacies, "where the conclusion does follow from the premisses," including *Ignoratio elenchi*, and *Petitio principii*, the latter including *Non causa pro causa*.

Mill gives us the following classification of Fallacies :—

A. Fallacies of Simple Inspection: *à priori* assumption of propositions without proof.

B. Fallacies of Inference :—

(1) Inductive:

(a) Fallacies of Observation: "of which the error lies in not sufficiently ascertaining the facts on which the theory is grounded; whether the cause of failure be mal-observation, or simple non-observation, and whether the mal-observation be direct, or by means of intermediate marks which do not prove what they are supposed to prove." (Mill, V. ii. 2.)

(b) Fallacies of Generalisation: arising from misconception of "the legitimate mode of drawing conclusions from observation and experiment." (Mill, V. v. 1.)

(2) Deductive: or, Fallacies of Ratiocination: arising from a violation of the formal rules of inference.

(3) Fallacies of Confusion, "in which the source of error is not so much a false estimate of the probative force of known evidence, as an indistinct, indefinite, and fluctuating conception of what the evidence is" (Mill, V. vii. 1.)

Welton has classified fallacies according to the logical principle violated, and has set down the following scheme,[1] which we consider very clear and simple :—

[1] cf. Welton, *Manual*, (1896). Vol. II. p. 235 ff.

A. Fallacies incident to Conception.
1. Faulty (or imperfectly conceived) Definition.
(a) Embracing incompatible attributes.
(b) Aristotle's *Equivocatio.*
(c) ,, *Figura Dictionis.*
(d) ,, *Secundum Quid.*
(e) ,, *Compositio* and *Divisio.*
2. Faulty Division.
(a) Change of *fundamentum divisionis*
(b) Non-exhaustive division.
(c) Omission of steps in division.
B. Fallacies incident to Judgment.
1. Judgment involving self-contradiction.
2. Misinterpretation of categorical propositions.
(a) Aristotle's *Amphibolia.*
(b) ,, *Accentus.*
3. Misinterpretation of hypothetical propositions.
4. ,, ,, disjunctive
C. Fallacies incident to Immediate Inference.
1. False Opposition, including Aristotle's *Plure interrogationes.*
2. Illicit Conversion.
(a) Of an A or O proposition.
(b) Aristotle's *Accidens.*
(c) ,, *Consequens.*
3. Illicit Contraposition.
4. Illicit Inversion.
D. Fallacies incident to Deductive Inference.
1. **Abstract.**
(a) Undistributed Middle.
(b) Illicit Process of the Major.
(c) Illicit Process of the Minor.
2. Concrete.—Four Terms—including (a) the use of a proposition involving any of the fallacies under A, 1, (b), (c), (d), (e), and B, 2.

E. Fallacies incident to Inductive Inference.
1. False Analogy, leading to wrong hypothesis.
2. Imperfect Observation.
3. Illicit Generalisation.

F. Fallacies incident to Method.
1. Taking as axioms propositions which are not self-evident.
2. Aristotle's *Petitio principii.*
3. ,, *Ignoratio elenchi.*
4. ,, *Non causa pro causa.*

3. **Imperfect Observation.**—We are not concerned here with fallacies in general, but with those incident to Induction alone. We shall, therefore, discuss Imperfect Observation, Illicit Generalisation, False Analogy, and also those incident to Method.

We have already spoken of the difficulties in the way of a thoroughly accurate observation, and have also referred to the conditions which a perfect and scientific observation must fulfil. We have now to point out the chief errors to which observation is liable. Mill says: " A fallacy of mis-observation may be either negative or positive; either Non-observation or Mal-observation. It is non-observation when all the error consists in overlooking or neglecting facts or particulars which ought to have been observed. It is mal-observation when something is not simply unseen, but seen wrong; when the fact or phenomenon, instead of being recognised for what it is in reality, is mistaken for something else.[1]

Fallacy of *Non-observation* : It arises when we overlook something that ought to have been observed. When we are investigating a phenomenon we sometimes overlook instances which are pertinent to our subject. This is mainly to be accounted for by our bias. We are

[1] Mill, *op. cit.*, V. iv. 1.

naturally inclined to pass over instances that go against our theories and emphasise those that go to further strengthen them. For instance, in the case of a friend we very often overlook such instances of his conduct as go against the opinion we have previously formed of him, while in the case of one towards whom we are not well disposed we exaggerate his faults and shortcomings and interpret even his good actions as bad. A father cannot form a very correct opinion of his son's character, since he sees only one side of it, and is naturally disposed to view some of the evil actions more leniently than others.

In science, the fallacy of Non-observation commonly arises when we take account of positive instances and neglect the negative. Instances both of the presence and absence of the phenomenon under investigation must be considered. We spoke of it above while treating of the Methods of Induction. "The most extreme case of non-observation," says Welton, "is the invalid inference that because a phenomenon has never been observed it is necessarily non-existent."[1] Non-observation is no proof of non-existence, unless the existence of a phenomenon necessarily involves its observation. Observation, being a selective process and involving implicit inference and depending upon previous knowledge, is highly complicated, and the danger of non-observation of instances or some operative conditions or circumstances attending upon or constituting a phenomenon is obvious. In sociology, politics, economics, etc., the subject-matter being very complex, there is always a great scope for this fallacy. The statistical method is sometimes used to determine the increase or decrease of a certain physical

[1] Welton, *Manual*, Vol. II. p. 263.

malady or mental disposition, but there is always a tendency to overlook some of the conditions, other than those pre-conceived, that may have operated in bringing about the phenomenon. For instance, a decrease in the number of convictions for drunkenness does not necessarily mean a decrease in the number of public-houses or of criminality itself, since such decrease may be due to other causes, such as special legislation, special vigilant measures adopted by the Municipality, the Police, or to the Temperance propaganda.

Fallacy of *Mal-observation*: The term means misinterpretation of the things of sense. The fallacy arises from a wrong observation of the instances pertinent to a subject. "The rustic who takes a tombstone brightened by the rays of the moon for a ghost, or who interprets a donkey's bray as the voice of a departed ancestor" commits the fallacy of Mal-observation. Illusions in general furnish a further example of Mal-observation. Looking at a tree from some distance, I mistake a cluster of leaves for fruits; or entering a dark room, I mistake a piece of rope for a snake. Such instances could easily be multiplied. Some common instances are given by Herschel: "If we plunge our hands, one into ice-cold water, and the other into water as hot as can be borne, and after letting them stay awhile, suddenly transfer them both to a vessel full of water at blood-heat, the one will feel a sensation of heat, the other of cold. And if we cross the two first fingers of one hand, and place a pea in the fork between them, moving and rolling it about on a table, we shall (especially if we close our eyes) be fully persuaded we have two peas."[1] Logic cannot help us much against

[1] Herschel, *Natural Philosophy*, Sec. 72. cf. Welton, *Manual*, Vol. II. p. 266.

such fallacies; it can at best warn us against their existence. This part of the subject, connected as it is with Illusion or mister-interpretation of sense-date, belongs to Psychology.

4. **False Analogy.**—Analogy suggests a hypothesis; consequently, false analogy will lead to a false hypothesis. This error chiefly arises when superficial likeness between two things is mistaken for essential resemblance. Sometimes an analogy does exist, but its force is wrongly estimated, and the inference based on it is taken to be more probable than it really is. This happens when the points of resemblance have been exaggerated to the detriment of the points of difference. When, however, no analogy actually exists, but we only *assume* its existence, the result will be an utterly wrong hypothesis, calculated to vitiate the whole scientific inquiry. We need not repeat here what we said above on the use of metaphorical language being a frequent source of false analogy. Analogy must also never be taken as strict proof.[1]

5. **Illicit Generalisation.**—All inductive fallacies involve illicit generalisation, since all induction involves generalisation. This is a most common form of fallacy. We generally argue about a whole class, when we mean only "some" or "most." We are disposed to be hasty in generalising from only a few observed cases, and assuming an assertion to hold good universally. When an exception is brought to our notice, we simply ignore it by saying that a rule may have exceptions. As De Morgan aptly puts it: "A rule may have exceptions, it is said; but this is hardly a correct statement. A rule with exceptions is no rule, unless the exceptions be

[1]See ch. III. *supra*.

definite and determinable: in which case the exceptions are exclusions by another rule."[1]

Again, this fallacy arises when we treat our empirical generalisations—which should never claim more than a high degree of probability—as universal laws. An empirical generalisation is based only on a *partial* analysis of our subject; hence, if it is treated as a law, its function is clearly misused. The subject of an inquiry must be analysed in its entirety before we can arrive at any universal law about its nature or behaviour. Again, when we study social and political phenomena, we can at best study only one or the other striking feature. But this gives us only an empirical generalisation, which has no right to be extended to other features or conditions not examined by us. If we do so, we have another case of Illicit Generalisation. A complete analysis of all conditions, positive as well as negative, is necessary to guard against this fallacy.

6. **Undue Assumption of Axioms.**—Now we proceed to a very brief consideration of fallacies incident to Method, and the first is that of Undue Assumption of Axioms. We know that all *proof* ultimately rests on self-

[1] *op. cit.*, p. 279. cf. "In our day nothing is more common than to hear and read assertions made in all the form, and intended to have all the power, of universals, of which nothing can be said except that most of the cases are true. If a contradiction be asserted and proved by an instance, the answer is 'Oh! that is an *extreme case.*' But the assertion had been made of *all* cases. It turns out that it was meant only for ordinary cases; why it was not so stated must be referred to one of three causes: a mind which wants the habit of precision which formal logic has a tendency to foster, a desire to give more strength to a conclusion than honestly belongs to it, or a fallacy intended to have its chance of reception. The application of the *extreme case* is very often the only test by which an ambiguous assumption can be dealt with". (*ibid.*, p. 270.)

evident truths called axioms or first principles. Axioms cannot be demonstrated, we can only convince ourselves of their truth by our own intuition. It is very difficult to determine which truths can be called axioms and which not, since some truths may be self-evident to some and not to others. Thus some people will go on rejecting axioms unduly as not self-evident. But, at the same time, there is also a tendency of accepting hastily certain truths as axiomatic which on further consideration have to be rejected. This tendency is more common than the opposite one, and a false assumption of axioms is largely due to a confusion as to the relation of thought and reality. This is, however, a question that leads us into Metaphysics.

7. **Petitio Principii.**—This is also known as 'Begging the Question,' and is committed when we assume the truth of that which we want to prove: in other words, when we take for granted the very proposition in dispute. This, according to Aristotle, is done in five different ways: (1) by assuming the very proposition to be proved, (2) by assuming a universal which involves it as a particular case, (3) by assuming a particular involved in it, when the conclusion is universal, (4) by assuming the proposition part by part, and (5) by assuming another proposition which necessarily implies the one to be proved.

A common example of this fallacy is to be found in the hypothetical adoption of a false line of argument, leading to *reductio ad absurdum*. We assume the conclusion to be proved, and starting with this as our premiss proceed to show that all other suppositions are thereby made absurd. Euclid too adopts this method in his Geometry. But he assumes what he wants to

disprove, and shows that his assumption makes other propositions absurd or conflicts with self-evident truths. Such indirect proof possesses its own utility, but it always falls short of the validity of a *direct* proof.

Two sub-forms of this fallacy may be noted, (1) the *hysteron proteron*, and (2) the *circulus in demonstrando*. The former is the case when the fallacy of *petitio principii* is committed in a single step of inference, *e.g.* ' A heated body expands, because the molecules move away from each other.' The fallacy sometimes lurks in the use of synonyms, *e.g.*, ' opium induces sleep, because it has a soporific quality.' Sometimes the use of a single question-begging epithet gives rise to this fallacy, *e.g.*, a new measure is called an *innovation* to prove that it ought to be opposed and rejected.

When, however, more than a single step separates the assumption of the conclusion as a premiss from its statement as a conclusion, the fallacy is called *circulus in demonstrando*, *circulus vitiosus*, or *arguing in a circle*. As a typical example, we quote Whately : " Some mechanicians attempt to prove, (what they ought to lay down as a probable but doubtful hypothesis), that every particle of matter gravitates equally. Why? Because those bodies which contain more particles ever gravitate more strongly, *i.e.*, are heavier. But (it may be argued) those which are heaviest are not always more bulky. No, but still they contain more particles, though more closely condensed. How do you know that? Because they are heavier. How does that prove it? Because all particles of matter gravitating equally, that mass which is specifically the heavier must needs have more of them in the same space."[1]

[1] Whately, *Logic*, p. 25 ; also quoted by Welton, *Manual*, Vol. II. p. 282.

8. **Ignoratio Elenchi.**—This is the fallacy of proving the wrong conclusion [1] When, instead[2] of proving the exact contradictory of our opponent's thesis, we prove something else which is mistaken for it, we commit this fallacy. This is the Aristotelian sense of the term, but at present it is used in a more modernised sense to include all arguments which are ' beside the point,' which ' prove the wrong conclusion ' and which ' miss the point at issue.' By itself the argument may be perfectly valid, but inasmuch as it evades the point at issue it is fallacious. For instance, we commit this fallacy when we say that the study of the classics or fine arts is useless because it serves no practical purposes, since such study may be defended on other grounds. It is not a complete answer to the thesis that such study is useful.

Zeno's famous paradox of Achilles and the Tortoise is a classical example of this fallacy. Achilles and a tortoise run a race. Achilles runs ten times quicker than the tortoise, consequently accepts a handicap of 100 yards. Now, it is stated that Achilles will never overtake the tortoise; for when the tortoise has run 10 yards, Achilles will still be 10 yards behind him, when these 10 yards are caught up, he will be 1 yard behind. When this one yard is caught, he will still be 1/10 of a yard behind the tortoise, and when this 1/10 yard too is caught up, 1/100 of a yard will still separate the two, and so on

[1] " the fallacy of surreptitious conclusion, the mistaking or obscuring of the proposition really at issue, whilst proving something else instead " Carveth Read, *op. cit.*, p. 398.

[2] " The ' elenchus ' was the technical name given to the final syllogism, in which the contrary or contradictory of the opponent's thesis was shown to be true and the thesis thereby disproved. Hence *Ignoratio Elenchi* is literally the ignorance of the syllogism required for ' clinching ' a point in this special way." Gibson, *op. cit*, p. 291.

to infinity. Hence, it is proved that Achilles will never overtake the tortoise.

Aristotle criticises this argument by bringing out the fact that it involves a confusion of infinite length with infinite divisibility of length. The tortoise has the advantage of 100 yards. Achilles must cover this space before actually overtaking the tortoise. The argument aims to establish that this space is an infinite magnitude, hence it can never be completely covered by Achilles. But instead of proving that this space is infinite, it only proves that it is divisible *ad infinitum*. Thus it fails to prove the point at issue, and therein lies the fallacy of *Ignoratio Elenchi*.

This fallacy is also committed when, instead of proving or disproving the whole proposition, we prove or disprove only a part, and emphasise that to the exclusion of the remaining part. The part selected is generally that which appears as the principal weak point in the adversary's argument.

Again, when we use an *illustration* intending thereby to make some difficult point easier, it generally happens that a wrong point, not intended to be connected with the illustration, is taken by the reader to be the meaning intended by the person using the illustration. Unless the point of analogy is clearly made out by the user of the illustration, and distinctly understood by the reader, the use of *illustrations* creates the fallacy of *ignoratio elenchi*.

One frequently comes acrcss various examples of this fallacy in the law courts, where counsels usually resort to this mode of argument when they are called upon to support a weak case. If there is no case, they sometimes begin to abuse the plaintiff's attorney or enter into all sorts of details and arguments which are entirely

irrelevant to the point at issue. Political debates, newspaper controversies, theological and philosophical discussions, are the usual field for the employment of such fallacious arguments.

The following are some of the minor forms of this fallacy :—

1. The *argumentum ad balcum*.—This is only an appeal to physical force. When people have no case at all and are convinced of the futility of reasoning out the point at issue, they sometimes appeal to physical force.

2. The *argumentum ad ignorantiam*.—This is an argument employed by the speaker who trusts to the ignorance of his hearers for the acceptance of his own statements.

3. The *argumentum ad populum*.—This is an "appeal to the gallery," not an appeal to reason. The mob-orator usually appeals to the feelings, prejudices and passions of the crowd instead of relevantly reasoning out the point under discussion.

4. The *argumentum ad verecundiam*.—An appeal to the people's veneration for authority, or to the dignity of those who hold the opinion.

5. The *argumentum ad misericordiam*.—An appeal to the people's sense of *pity* ; *i.e.*, instead of proving the *innocence* of a person we try to show that he deserves *pity*. In murder cases, for instance, the defence counsel usually employs it when he cannot prove the defendant "not guilty."

6. The *argumentum ad hominem*, or "*tu quoque*" argument.—In which a reference is made to the previous history of a man to shew that he could not consistently hold certain views. Not only the charge of inconsistency, but recrimination and personal abuse are also sometimes resorted to. If, however, the personal character of a party is *relevant* to the truth of its statements, this

fallacy is not committed, and the counsel can have full liberty in impeaching its veracity by a reference to the personal character.

9. **Non Causa Pro Causa.**—This fallacy, also known as "False Cause" consists in assuming without sufficient proof that one thing is the cause of another. It usually occurs in cases of the *reductio ad impossible*, or indirect proof. In this mode of proof we endeavour to show that the statement of our opponent leads to an absurd conclusion. We either disprove a statement by showing that its assumption would lead to an absurd conclusion, or prove it by showing that the assumption of its falsity would lead to absurdities. When these absurdities do not follow from the statement actually made but from some other irrelevant proposition put into the argument, we commit the fallacy of *non causa pro causa.* For the same reason this fallacy is also called by Aristotle *non per hoc, non propter hoc, i.e.,* "your conclusion is absurd, not because of your assumption about my thesis, but quite independently of it."

This fallacy includes, according to Aristotle, all cases in which a conclusion is drawn from irrelevant premisses; in other words cases of *Non Sequitur.*[1] In the Aristotelian sense, this fallacy was peculiarly applicable to dialectical disputations; and in modern times it occurs under another form known as *post hoc, ergo propter hoc.* Instead of establishing a real connexion between the cause and effect of a phenomenon, we mistake for a cause something which is not really so. This generally results from our shirking the long intellectual process necessary

[1] That is, "arguments so foolish and inconsequent that they cannot even be said to simulate cogency ; these cannot be positively characterised, but must be lumped together by the mere negative mark of inconclusiveness." Joseph, *op. cit.*, p. 529.

to establish a true relation of cause and effect. We hastily assume that events which happen together in our experience a number of times are causally connected. Professor Creighton rightly traces this fallacy to "a particular form of mental sluggishness." "Two events occur in close conjunction with each other, and it is then assumed without further investigation that they are related to each other as cause and effect. Many popular superstitions are examples of this fallacy. Some project begun on Friday turns out disastrously, and it is inferred that some causal relation existed between the fate of the enterprise and the day on which it was begun. Or thirteen persons sit down to dinner together, and some one dies before the year is out."[1] Thus the fallacy of *post hoc, propter hoc* arises when we confound sequence or coexistence in time with causality.

SUMMARY.

A Fallacy is an error violating a logical principle and possessing a semblance of validity.

Several schemes of classification of fallacies have been proposed. For Aristotle's, Mill's, Welton's, etc., (see above).

The principal fallacies incident to Inductive Inference are Imperfect Observation (Non-observation and Mal-observation), Illicit Generalisation and False Analogy; and those incident to Method are—Undue Assumption of Axioms, Petitio Principii, Ignoratio Elenchi, and Non Causa pro Causa.

[1]J. E. Creighton, *Introductory Logic,* (Macmillan), 1909, p. 310.

Non-observation.—Overlooking facts or operating conditions which ought to have been observed. Due mainly to bias or prejudice.

Mal-observation.—Observing wrongly. Illusions furnish a common example. Sense-data are misinterpreted.

False Analogy.—Mistaking superficial or partial resemblance for essential likeness. Use of illustration a common source of this fallacy. It leads to false hypothesis.

Illicit Generalisation.—Generalising for a class when we really mean " some," and treating empirical generalisations as universal laws.

Undue Assumption of Axioms.—Hastily accepting certain truths as self-evident, when they are not actually so.

Petitio Principii.—Begging the question : taking for granted the very proposition to be proved. (Note its five forms, *supra*).

Ignoratio Elenchi.—Proving the wrong conclusion; mistaking or obscuring the proposition really at issue, and proving something else.

Non Causa pro Causa.—Assuming without sufficient proof that one thing is the cause of another. More common form " Post hoc, ergo propter hoc," the mistaking of temporal sequence or coexistence for causality.

QUESTIONS AND EXERCISES.

1. Distinguish between *error* and *fallacy*. Bring out the meaning of *sophism*, *paralogism*, *paradox*.

2. Describe the classifications of Fallacies by Aristotle, Mill and Welton, respectively. Give any other classification, of your own, if possible.

3. Name the fallacies incident to Induction, and give examples to illustrate them.

4. Illustrate the various forms of the fallacy of *Petitio principii*, and *Ignoratio elenchi*.

5. What fallacies are to be avoided in *observation*, *generalisation*, and *analogy*?

6. Examine logically the following arguments, pointing out the fallacies, as the case may be:—

(a) " If it be said that there is an evil in change as change, I answer that there is also an evil in discontent as discontent."

(b) " I speak not from mere theory. There exist at this moment practical illustrations of my assertions."

(c) An adverse decision, my lords, will seriously prejudice the political prospects of my client. I beg you therefore to weigh well a decision which, if unfavourable, will spell disaster for an honourable man.

(d) Who can deny that this measure will ameliorate the lot of our fellow-citizens when we reflect that it will raise the standard of comfort in every home.

(e) " He has spoken of that noble person and of his intellect in terms which, were I disposed to retort, I might say show the hon. gentleman to be possessed of an intellect which would justify me in passing over in silence anything that comes from such a man."

(f) No man can witness the daily misery and oppression of the poor in our land without being stirred to redress their wrongs. I need say no more. That will be sufficient for all enlightened men to support this reform which has no other aim than to relieve their distress. (Welton).

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